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INFILTRATION RATE AND SEDIMENT PRODUCTION OF SELECTED PLANT COMMUNITIES AND SOILS IN FIVE RANGELANDS IN NEVADA

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ABSTRACT

Simulated rainfall (1.5 inch per hour for 60 minutes duration and 3-inch per hour for 30-minutes duration) was used to study infiltration rates and sediment production of 28 plant communities and soils of five watershed areas in central and eastern Nevada. Two soil moisture conditions were used, soil initially dry and initially at field capacity.

Infiltration rates and sediment production for the various plant communities and soils vary considerably within watersheds and between watersheds.

Infiltration rates and sediment production of the various soils are largely controlled by dune interspace extent and its soil surface morphology. Vesicular horizons are found unstable in dune interspace surface soils but seldom occur in coppice dunes or in well aggregated dune interspace soils. Infiltration rate is negatively related and sediment production positively related to occurrence of a vesicular horizon and its morphology.

Significantly more sediment is produced from soils that are initially at field capacity than those that are initially dry. This is due to the instability of surface when saturated.

Vegetation conversion treatments may take a long time before they significantly affect infiltration rates or sediment production. If dune interspace soil surface is well aggregated and free of a vesicular horizon before treatment, there may never be a significantly larger infiltration rate or lower sediment production realized for the treated site.

Soil hydrologic groups as now described give a very poor estimate of infiltration rates in the arid west and trying to modify them creates more problems. More meaningful groups are developed using surface soil characteristics. (Key Words: simulated rainfall, infiltration, sediment, plant community, soil, dune interspace, coppice dune, vesicular horizon, vegetation conversion, hydrologic groups).

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INTRODUCTION

High intensity summer thunderstorms in the Great Basin account for most of the runoff and sediment production from rangelands. Runoff is the major force initiating soil movement and transporting sediment to rivers and reservoirs. in order to effectively manage rangeland watersheds, infiltration rates and sediment production of the different plant communities and soils need to be known. Likewise, factors influencing infiltration and sediment production need to be understood. However, for Nevada's rangeland there is practically no information on infiltration and sediment production, nor on the influence of dune interspace areas and associated vesicular horizons on infiltration and sediment production.

This cooperative study was initiated July 1969, by the Bureau of Land Management and Nevada Agricultural Experiment Station. It was intended to measure infiltration rates and sediment production of selected plant communities and soils of central and eastern Nevada under simulated rainfall. The specific study objectives were:

1. To determine infiltration and sediment production relationships for selected plant communities and soils.
2. To determine which ground cover and soil parameters influence infiltration and sediment production.
3. To develop more useful parameters for classifying hydrologic soil groups and subgroups.

Twenty-eight plant communities and/or soils representing pinyon-juniper, northern desert shrub, and salt desert shrub vegetation zones were studied in five watershed areas in central and eastern Nevada. The soils are mostly Aridisols and a few are Mollisols and Entisols. Thunderstorms of two different intensities were simulated using an infiltrometer. A 3-inch per hour storm was used to simulate the exceptional thunderstorm and to assure site infiltration rate was exceeded. In addition, a 1.5 inch per hour storm was used to simulate a more normal thunderstorm intensity. Detailed descriptions of cover and soils were made and special attention given to the soil surface horizon. The data were analyzed by multiple regression, correlation, and analysis of variance techniques.

LITERATURE

Infiltration and erosion on rangelands have been studied for sometime. Reviews of the literature include Chapline, 1929; Forsling, 1932; U.S.D.A., 1940; Harper, 1953; Gifford, 1968b; Branson, Gifford and Owen, 1972. The review which follows will familiarize the reader with work to date in areas related to this study.

INFILTRATION

Infiltration is the passage of water through the soil surface. The rate water can enter a soil is dependent on many factors. Most factors are in two general groups: (1) those affecting the protective cover of the soil surface, and (2) those associated with the soil. Precipitation rate and topography may also affect infiltration.

Cover Factors

Plant and litter cover - Plant and litter cover are important parameters influencing infiltration rates (Aldon, 1964; Beutner, Gaebe and Horton, 1940; Kincaid and Williams, 1966; Doty and Carter, 1965). Dortignac and Love (1961) studied infiltration rates on ponderosa pine ranges of Colorado and found that plant and litter cover was highly positively correlated with infiltration. Rauzi, Fly and Dysterhuis (1968) studied water intake on midcontinental rangelands and concluded that the amount of new and old vegetation showed the greatest general correlation with water intake rates. Meeuwig (1970b) found the amount of live vegetation to be an important and highly correlated variable with infiltration rates in northern Utah.

Marston (1952), and Bailey and Copeland (1961) studied ground cover requirements on high elevation watersheds in nothern Utah for summer storm runoff control. They concluded that 65 percent of the ground must be covered with vegetation and litter to prevent excessive storm runoff. Packer (1951) states that adequate control of summer storm runoff on wheatgrass [*Agropyron inerme*] rangeland requires at least 70 percent plant and litter cover, and the bare openings should be no larger than 4 inches. On cheatgrass [**Bromus tectorum**] range, 70 percent ground cover is also required, but bare openings should be no larger than 2 inches.

Rauzi (1960) showed that regardless of the soil type on midwest rangelands, water intake rates depend on the type of plant cover, the amount of standing vegetation and the amount of litter. Duley and Domingo (1949) in a similar study concluded that the amount of grass and associated litter was more important than the kind of grass or soil type. It has also been demonstrated on midwest rangeland that plant and litter cover have a greater affect on infiltration rates than slope, intensity of rainfall or soil type (Duley and Kelly, 1939). Woodward (1943) studied infiltration rates on vegetative-soil complexes in central Utah and found that infiltration rates increased directly with increased plant cover. However, magnitude varied between cover types and soils.

Rock cover -Musgrave (1955) studied infiltration rates in eastern U.S. and noted that rocks on the soil surface provide protection against raindrop impact and higher infiltration rates could be expected on sites with rocks than sites devoid of rocks. Haupt (1967) observed on the east slope of the Sierra Nevada that fairly large exposed rocks apparently accelerated the runoff process by concentrating the flow in surface openings between the rocks. Meeuwig (1971b) worked on high elevation rangeland in the intermountain area and found the surface one inch composed of aggregates and particles larger than 0.5 mm to be positively correlated with infiltration. Likewise, Jager (1972) found in the Eastgate Basin of Nevada that infiltration increased as rock cover larger than 2 mm increased.

Bare ground - Another way to treat this relationship is to consider that area not receiving protective cover from plants, litter or rock. Duley and Domingo (1949) stated that where a stand of grass is poor and much ground is not covered, the intake rate may be reduced in proportion to the amount of bare ground. Marston (1952) studying ground cover requirements for summer storm runoff control on aspen sites in northern Utah found that with a 3-inch per hour storm as much as 45 percent runoff may be expected from bare ground, and to keep runoff during such storms to less than 5 percent requires a ground cover of at least 65 percent. Jager (1972) found infiltration rates to be negatively correlated with percent bare ground. Branson and Owen (1970) studied plant cover and runoff relationships on Mancos Shale in western Colorado. They found

that percent bare ground was highly positively correlated with runoff (R=0.86), more so than plant cover plus litter and rock.

Vegetation type - As Woodward (1943) noted, infiltration rates may differ from one vegetation type to another. Branson, Miller and McQueen (1965) studied in eastern Colorado the intake rates of two vegetation types (buffalo grass and western wheatgrass) growing on soils derived from shale. They showed that the buffalo grass type had an infiltration rate better than double that of the western wheatgrass type. They later studied 10 vegetation types in northeastern Montana and found the infiltration rates were low and varied from 0.5 inch per hour in a wheatgrass type to 1.3 inches per hour in a silver sagebrush type (Branson, Miller and McQueen, 1970). Smith and Leopold, (1941) studied infiltration rates in grassland, woodland and desert shrub types of the Pecos River Watershed, New Mexico and Texas. They found that there was not a significant difference between grassland and woodland types. However, between grassland and desert shrub, and between woodland and desert shrub there was significant difference in infiltration rates. Box (1961) studied infiltration rates in south Texas on bare soil, grass sod and brush cover. He found the lowest rates through bare soil and highest under grass sod, and that all vegetation improved water intake but grass proved superior to brush.

Plant succession - Dee, Box and Robertson (1966) in Texas found infiltration rates to increase with the increasing position of a plant in the successional scale, the stage of succession of the community, the amount of standing vegetation and litter. They showed that infiltration rates in soil under different successional stages were significantly different from each other. Rauzi and Zingg (1956) noted on midcontinental rangeland that intake rates could be approximately doubled on most soil textural groups through improvements in range condition. Leithead (1959) states that Texas rangeland in good condition absorbes moisture five to six times faster than the same range site in poor condition. Craddock and Pearse (1938) recognized the importance of good range condition in decreasing runoff on granitic mountain soils in Idaho.

Shrub-grass and grassland conversion - Dragoun (1969) compared surface runoff before and after conversion from cultivated crops to permanent prairie grass. He found seeding to native grasses provided approximately 90 percent reduction in surface runoff the second year after planting. Three years after planting the hydrologic performance of the seeded areas was similar to that of the virgin prairie with little surface runoff. Surface runoff was reduced in the lower chaparral zone in Arizona by establishing a perennial grass cover. This was done by cutting woody vegetation and grubbing its roots, sloping steep gully sides, placing cut brush in gully channels and seeding to grass. Rowe and Reimann (1961) found in the San Gabriel mountains of southern California that conversion from brust to grass produced a small increase in surface runoff before the grass was established. However, since establishment of a complete grass cover, no appreciable amount of runoff occurred from the study plots. Kincaid and Williams (1956) studied the effect of brush removal, pitting and seeding on surface runoff in the Walnut Gulch Experimental Watershed, Arizona. They concluded there was little correlation between treatments and surface runoff, although clearing appeared to increase runoff, and seeding appeared to reduce it. Tigerman (1952) reported that disturbance by overgrazing, reseeding, or burning will reduce the infiltration capacity of sagebrush range sites. Gifford and Skau (1967) and Jager (1972) studied the influence of cultural practices on runoff from the big sagebrush cover type in the Eastgate Basin, Nevada. They found that for the first and third year after treatment plowed plots had lower infiltration rates than control plots. The infiltration rates on the rip and drill plots were approximately the same as those on the control plots. Gifford (1972) studied a native and seeded big sagebrush site in southern Idaho. He indicated that the trend was toward lowered infiltration rates following plowing and seeding. The greatest decline occuring during the fall season of the second year after treatment. Seven years after disking and seeding a subalpine range in central Utah to grass, Meeuwig (1965) found the surface soil of the seeded sites had a significantly lower capillary pore space and significantly higher bulk density than the unseeded sites. Noncapillary porosity, although not significantly different, tended to be greater on the seeded sites and mean protective cover was significantly less on seeded plots than on native ones. Mean runoff was greater on seeded sites than on native sites, although the differences were not significant.

Pinyon-juniper wildland conversion - Skau (1961) indicated that the pits created by cabling, and the juniper debris left on the ground in the Beaver Creek watershed, Arizona, helped to reduce the amount of surface water flow. Skau (1964b) further states that clearing pinyon and juniper may considerably increase water available for forage production, and clearing will have little effect on water yield insofar as influenced by soil water storage in the upper 24 inches. Brown (1965) reports that after two years of post-treatment measures of cabled Utah juniper watersheds, there has been no significant change in summer or winter water yield. He noted, however, that herbage production, primarily of forbs and half shrubs has increased following treatment, that bare ground was reduced 13 percent following treatment and litter increased 16 percent. This agrees with the findings of Collings and Myrich (1966) and Brown's (1970) later results. Gifford, Williams and Coltharp (1970), and Williams, Gifford and Coltharp, (1969, 1972), studied treated and untreated pinyon-juniper sites in central Utah and found cleared areas of pinyon-juniper seeded to grass showed no consistent decrease or increase in infiltration rate. Gifford and Tew (1969) stated that mechanical acitvity associated with chaining and windrowing of pinyon-juniper significantly increases permeability of surface soils during the first year following treatment. Treatment with debris in place was less effective in increasing infiltration. They indicate the increase in soil permeability associated with windrowing was probably due to an increase in noncapillary porosity through decreased bulk densities and incorporation of litter into the surface soils.

SOIL FACTORS

Texture - In general, water intake rates are lowest on sites characterized by fine-textured unstable soils and highest on range sites characterized by coarse-textured soils (Rauzi, Fly and Dysterhuis, 1968; Baver, 1933; Rauzi and Zingg, 1956. Smith and Leopold, 1941; England and Stephenson, 1969; Jager, 1972; Gifford and Skau, 1967). Allis and Kuhlman (1962) studied runoff from fine and medium textured soils in the northern Great Plains. They observed three times more runoff from the fine textured soil than the medium textured soil. Dortignac and Love (1961) found sand content to be the best indicator of the influence of texture on infiltration. Musgrave (1955) devised a runoff classification system where he rated soils in four hydrologic groups on texture along with drainage, depth and subsurface soil conditions.

Rauzi and Kuhlman (1961) studying water intake as affected by soil and vegetation on South Dakota rangeland, observed a reduction in infiltration rate after 15 minutes because of a clay pan. They further state that infiltration differences between soils is not just a function of surface texture. Dense sub-soil, such as clay pans, and thin soil over shale parent materials can inhibit the rate of water intake, especially after the surface horizon becomes saturated.

Structure - Rauzi, et al., (1968) found the soil structure of the first horizon to be highly correlated with water intake. O'Neal (1949) concluded that structure was probably the most significant factor in evaluating permeability. However, he found it difficult to evaluate permeability only on the basis of structural factors.

Depth - Musgrave (1955), and England and Stephenson (1969) indicate that the infiltration for different soils are correlated especially well with soil depth, particle size and organic matter.

Bulk Density - Bulk density is related to porosity in the following manner (USDA, 1954(:

$$N = (dp - db)/dp$$

Where N = Porosity, dp = Particle density, db = bulk density. The lower the bulk density the higher the porosity and generally the higher the infiltration. Meeuwig (1970b) found the bulk density of the surface 4 inches to be negatively correlated with infiltration. Dortignac and Love (1961) found noncapillary pore volume to be the most important soil factor related to infiltration.

Organic matter - Organic matter in the soil is probably the major agency in the encouragement of granulation, especially as it undergoes decay and is gradually synthesized into humus. Organic matter not only binds the soil into aggregates but lightens and expands it, thus, increasing the porosity. Baver (1933) working in Missouri found that intake rate increased as the degree of granulation and organic matter increased. Musgrave (1955) and Jager (1972) also observed that as organic matter increased so did infiltration rates. However, Meeuwig (1971a) found this was not always true. He states that there are zones within sandy soils of the Carson Range of the Sierra Nevada that have little affinity for water, in fact, they repel water because the

water, in fact, they repel water because the surface is coated with hydrophobic organic substance. Repellency depends on severity of hydrophobic organic substance and its distribution within the soil mantle.

Cracks - Soils .like Vertisoils that crack to the surface when dry will increase the amount of water that will be absorbed by the soil (Rauzi and Kuhlman, 1961; Musgrave, 1955).

Entrapped air - Christiansen (1944) using soil packed in cylinders found that some air was trapped in the soil regardless of whether the water was applied from the top, from the bottom by capillary, or under a head. He concluded that entrapped air caused a large reduction in permeability as compared with completely saturated soils.

Dixon and Linden (1972) studying infiltration rates of Nevada's irrigated land found that when a given amount of water soaks into dry soils it forces out an equal volume of air. If something restricts air from leaving the soil, air pressure builds up and slows infiltration rate. This soil air pressure blocks the flow of water into large soil pores but not small pores. If soil air pressure is greater than hydrostatic pressure the large pores serve only to vent soil air upwards. But if hydrostatic pressure is greater than air pressure the large pores can fill with water and serve as arteries to conduct surface water quickly into the soil. Dixon (1972) states further that rough interfaces with open macropores produce rapid rates and direct routes of water penetration, whereas, smooth interfaces with closed macropores produce slow rates and tortuous routes.

Microorganisms - McCulla (1942) investigated the effect of adding microbial decomposition products of plant residues to a soil low in organic matter. His work indicated that microbial by-products increased the water stability of the soil structure which increased the infiltration rates.

Moisture - Smith and Leopold (1941) stated that initial soil moisture was as important as any other factor on infiltration. Meeuwig (1970b) found initial moisture content of the surface 2 inches of soil an important parameter in explaining infiltration rates. Higher infiltration rates are observed in soils which are initially dry than those that have been soaked and allowed to drain 24 hours before infiltration tests start. (Gifford 1968a).

Season of year - Bertoni, Larson and Shrader (1958); Musgrave (1955); Schumm and Lusby (1963) and Gifford (1972) have shown that as the year progresses from spring to fall infiltration rates decrease. Gifford found in southern Idaho higher infiltration rates in the spring resulted from increased porosity caused by freezing and thawing over winter, and that as the summer progresses, drying of the soil, soil microorganism activity and rainfall (which disturbs and/or seals the soil surface) all contribute to lower infiltration rates. Also, as grazing is imposed on the area, the additional compaction and removal of plant materials also influence a lower infiltration rate as the season progresses.

Soil type - Parr and Bertrand (1960) indicated that infiltration capacities will vary between soil types. However, Woodward (1943), and Duley and Kelly (1939) found the infiltration rates on different soil types to vary depending on the vegetation and litter present, thus making it hard to assign an infiltration rate to a soil.

Hydrologic groups - Musgrave (1955) introduced the concept of grouping soils according to their in-place infiltration capacity after prolonged wetting. Soils were classified in four hydrologic soil groups, i.e., A, B, C, and D with A having the highest and D the lowest intake rates. A set of criteria were also provided for each soil group, which was based mainly on texture. Rauzi and Kuhlman (1961) studying intake rates on western South Dakota rangeland indicated that the differences between soils is not only a function of surface texture, but that dense sub-soils and thin surface soils over shale parent materials can inhibit the rate of water intake, especially after the surface horizon becomes saturated. Ogrosky and Mockus (1964) modified the criteria of Musgrave by adding drainage classes and impeding strata. The criteria for the four hydrologic groups, as used by the Soil Conservation Service, are as follows (USDA, 1964):

Group A. (low runoff potential): Soils having high infiltration rates even when thoroughly wetted and consisting chiefly of deep, well to excessively drained sands or gravels. These soils have a high rate of water transmission.

Group B. Soils having moderate infiltration rates when thoroughly wetted and consisting chiefly of moderately-deep to deep, moderately well to well-drained soils with moderately-fine to moderately-coarse textures.

These soils have a moderate rate of water transmission.

Group C. Soils having slow infiltration rates when thoroughly wetted and consisting chiefly of soils with a layer that impedes downward movement of water, or soils with moderately fine to fine texture. These soils have a slow rate of water transmission.

Group D. (high runoff potentials). Soils having very slow infiltration rates when thoroughly wetted and consisting of clay soils with a high swelling potential, soils with a permanent high water table, soils with a clay pan or clay layer at or near the surface, and shallow soils over nearly impervious material. These soils have a very slow rate of water transmission.

Chiang and Peterson (1970) indicate that over 4,000 soil series in the United States have been classified in the four hydrologic soil groups according to the Soil Conservation Service criteria. They suggest a refinement of the four hydrologic groups by using soil catena diagrams and the criteria in the new Soil Classification System (USDA, 1970). They define soil catena as a group of soils developed from a similar parent material but differing in drainage. The new classification readily provides information that can be used to indicate soils of different drainage, i.e., shallow soils by lithic or shallow; fragi or duri indicates a pan and aqu indicates a wet soil. They state that the use of soil catena based on the new classification provides for intermediate ratings of +B, +C, and +D groups, and if a soil is skeletal and has impermeable substrata, it should be classified in the next higher hydrologic soil group. In light of the work that has been done on hydrologic groups a few workers feel that most subsurface layers do not influence infiltration that much. Duley and Kelly (1939) indicated that heavy clay layers in the subsoil of Pawnee clay loam and Butler silt clay loam probably do not retard infiltration to any extent and would have little effect on runoff under climatic conditions prevailing in Nebraska.

Compaction layer. - Often at the surface of a bare soil there is a 0.5 to 1 mm thick, dense, non-vesicular, massive surface layer developed which will result in lowered infiltration rates. Lowdermilk (1930) states that this layer results from filtering suspended soil particles from water. Duley and Kelly (1939) suggest the compacted layer is formed by the breaking down of soil structure, by the compacting effect of rain and the rearranging of the soil particles by running water. They and Osborn (1950) found these compaction layers to be the principal reason for low infiltration rates.

Vesicular surface horizon - Lapham (1932) observed vesicular surface horizons in virgin Portneuf silt loam, the then dominant recognized soil of southern Idaho, and attributed the vesicular porosity formation to imprisonment of air by showers during dry periods. Hugie and Passey (1964) studying some semiarid soil in the Intermountain area observed bubbles of escaping gas through supersaturated surficial horizons of soil with polygonal surface patterns. They theorized that as the fluid surficial horizon dries, it gradually passes from a liquid phase to a solid phase and escaping gas becomes trapped forming vesicular pores. Higher temperatures near the soil surface cause expansion of trapped gas and possibly accounts for the concentration of larger vesicular pores near the surface. Bull (1964) attributed vesicular porosity in mudflow in western Fresno County, California, to air in the underlying soil being entrapped in the mudflow. Springer (1958) reproduced vesicular pores similar to those occurring naturally by wetting and drying sieved soil samples from a vesicular horizon. He noted that as water infiltrated into the sieved soil materials, the particles became rearranged and closely packed, and air appeared to collect into larger pores. Some air bubbles moved toward the top of the soil sample and escaped, and soil particles and voids were continually rearranged by repeated wetting and drying. He concluded that vesicular porosity was unstable, transitory, and quickly reformed in certain soils. Miller (1971) studied vesicular pore formation under furrow irrigation and speculated that a platy structure develops first. Then, with continued wetting and drying, the pores between platelets became spherical and the spheres became larger. He also noted all of the soil exhibited considerable swelling and shrinking with wetting and drying. The bulk density of the surface decreased with a number of wetting cycles. Miller concluded that soils involved in vesicular pore formation are very unstable when nearly saturated and the air pressure is sufficient to form the cavity between platelets into a sphere, thus achieving the smallest surface area per unit volume. More air is entrapped in the soil with each wetting and drying cycle. Then in wet, fluid

soil, small vesicules merge into larger ones because the surface area per unit volume decreases as the vesicules enlarge. Vesicules remain air-filled during water application. He speculated that vesicular porosity had little influence on infiltration rates, and that the formation of a surface compaction layer was much more important in determining the infiltration rates. Volk and Geyger (1970) observed in many warm-arid areas of the earth there are patches free of vegetation distributed in a mosaic-like pattern, although the precipitation is sufficient for plant growth. These "scalded areas" are not necessarily caused by overgrazing or soil salinity. They made extensive observations in southern Spain, Morocco, and southwest Africa and found near the soil surface a structure formation they designated as "foam structure" (vesicular porosity). It is marked by an accumulation of spheroidal vesicles with smooth walls which generally are isolated within the soil matrix. They found the vesicular porosity to prevent penetration of precipitation and speculated that if the soil surface is broken up such areas may become covered with plants for a certain time.

Coppice dune and dune interspace areas - Stuart, Schuman and Dylla (1971) use coppice dune to describe the dunes collected around and under shrubs and formed by very fine sands and silt blown off the floodplain of the Humboldt River and its tributaries, and off the recently dried-up Pleistocene lakes or playas throughout the rest of the Great Basin. In this study, coppice dune is defined as the area of accumulation of litter and soil under shrubs or bunch grass and the areas between as dune interspace. Pearse and Woolley (1936) studied the influence of range plant cover on infiltration rates and found plots supporting bunch grasses absorbed water 0.0453 inch per minute faster than the corresponding interspaces, an increase of 127 percent due to the presence of fibrous rooted species. Plots supporting tap rooted species [*Balsamorhiza sagittata, Lupinus caudatus*] absorbed water 0.02 inch per minute faster than adjacent plots in interspace areas, an increase of 51.5 percent. Duley and Domingo (1949) found where a stand of grass is poor and much ground is not covered, the intake rate may be reduced in proportion to the amount of bare ground. However, since the intake rate is higher within the tufts of grass, they may absorb some water that runs off the interspace areas. Lyford and Qashu (1969) studied the infiltration rates into two soils measured at radial distance from the stems of paloverde [*Cercidium microphyllum*] and creosotebush [*Larrea tridentate*]. They found infiltration rates to be nearly three times greater in the coppice dunes than in the dune interspace areas. They also found that bulk density was lower and organic matter content was higher in the top soil under plants than in the openings.

Precipitation

Application rate - Duley and Kelly (1939) found no significant difference in the rate of infiltration due to difference in rate of application when the application rate exceeded the intake rate. Osborn and Lane (1969) studying precipitation-runoff relations for very small semiarid rangeland watersheds, found the peak rate of runoff was most strongly correlated to the maximum 15-minute depth of precipitation.

Topography

Surface roughness - Jager (1972), and Kincaid and Williams (1966) found that soil surface roughness, as recorded by a micro-relief meter, was not significantly correlated with infiltration.

Slope - Beutner, Gaebe and Horton (1940), and Duley and Kelly (1939) have indicated that infiltration is little affected by slope. Duley and Kelly found infiltration rates to decrease only slightly with increased slope and what little change occurred was very small on slopes above 2 percent. They also indicate that other factors such as vegetation and litter cover have a greater effect than slope.

EROSION

Erosion in a broad geologic sense means the wearing away of the earth's surface by the forces of water and wind, which can be either beneficial or detrimental depending on the type of erosion.

Natural or geologic erosion occurs on land under natural environmental conditions not disturbed by human activities. It is the chief agent responsible for the natural topographic cycles, as it wears down the higher points of elevation and constructs alluvial plains in the valleys. Perhaps one-third of the world's population get their food supply from alluvial soils and from young soil developed on alluvium.

Accelerated erosion results from disturbance of the natural landscape, usually by man. This type of erosion can result from exposure of the soil through burning, excessive grazing, forest cutting, and tillage, any of which destroy or weaken the vegetation.

Water erosion results from the forces of flowing water and abrasion when runoff passes over soil surfaces. A part of the process is due to raindrop impact which detatches soil particles and suspends them in the runoff. There are basically three types of erosion: sheet, rill and gully. Sheet erosion is the more or less uniform removal of soil from an area, without the development of conspicuous water channels. Rill erosion is the removal of soil through cutting of numerous small inconspicuous water channels. Gully erosion refers to the most conspicuous form of water erosion where relatively large channels are cut into the soil by concentrations of runoff (USDA, 1951).

Gleason (1953) and Bennett, Bell and Robinson (1951) state that geologic erosion proceeds so slowly as to go practically unnoticed and as a rule is probably beneficial and seldom harmful. The fact that residual soil exists on sloping land is evidence that under natural conditions the process of erosion is even slower than the extremely slow process of soil formation. Nikiforoff (1942) reported geologic erosion as the process that removes from the surface drying off material as fast as it forms, thus continuously exposing fresher materials to weathering. This provides a continuous flow of energy and matter into the zone of pedogenesis. Marbut (1940) discussing normal soil profiles states, "It is readily apparent. . . . that the normal profile in any region is found in soils which occupy situations in which the material from which the soil has developed, has lain for a relatively long period of time without subjection to removal by erosion. These soils have reached a relatively advanced state of development in which the forces causing development have had time to produce their normal effect on a given material and where local conditions have either had no inhibiting effects or else that effect has been overcome." Smith and Stamey (1965) state that Marbut's reference to the absence of erosion during development of a normal soil, therefore, should probably be interpreted as indicating that he considered geologic erosion as being too slow to be considered significant during the development of a soil on moderate slopes with virgin vegetation. Smith and Stamey (1965) give the rate of geologic erosion on short slopes in the United States covered with a mantle of agricultural soil and an annual precipitation of 20 inches or more as less than one ton per acre annually and more commonly in the order of 0.05 to 0.30 ton per acre. Chamberlain (1909) stated "Without any pretensions to a close estimate, I should be unwilling to name a mean rate of soil formation greater than 1 foot in 10,000 years on the basis of observations since the glacial period." This would be less than 0.2 tons per acre annually. Smith, Whitt and Miller (1948) gave erosion tolerance standards for Missouri as: 4 tons per acre annually for Marshall and Shelby, and related soils; 3 tons for Putnam and other clay pan soils; 2 tons for sloping soils of the Ozarks. Thompson (1952) indicated that the permissible annual soil losses estimated for Iowa were as follows: 6 tons per acre per year for permeable soils over permeable, unconsolidated material; 4 tons for soils with slowly permeable subsoils over unconsolidated materials; 1 ton for deep soil on bedrock; and 0.5 ton for shallow soil on bedrock. Smith, et. al. (1954) suggested a 2 ton per acre annual loss as tolerable on deep soils of the Blackland prairies in the southwest.

Glymph (1957) found in half of 113 watersheds east of the 100 meridian sheet erosion accounts for 90 percent or more of the sediment yield. He feels that sheet erosion is a major contribution in the eastern United States. However, Smith and Wischmeier (1962) concluded that the removal of a uniform layer of soil can only be accomplished by raindrops and that, as soon as runoff begins, rills start to develop and erosion no longer continues uniformly.

Soil erosion is a complex process, the rate at which it occures depends primarily on four classes of variables; cover factors, soil factors, precipitation and topography.

Cover Factors

Plant and litter cover - It has been well established in the literature that plant and litter cover are important parameters in reducing soil erosion (Smith and Wischmeier, 1957; Meeuwig, 1970a; Meeuwig, 1970b; Smith and Wischmeier, 1962; Rich, 1961; Gifford and Skau, 1967; Doty and Carter, 1965; Orr, 1970; Packer, 1963; Jager, 1972; Aldon, 1964; Bailey and Copeland, 1961).

Generally, as plant and/or litter cover increases sediment decreases (Doty and Carter, 1965). Meeuwig (1970b), and Smith and Wischmeier (1962) found vegetal cover to be the greatest deterent to soil erosion because it breaks raindrop impact. Orr (1970) studied erosion in the Black Hills of South Dakota and concluded that as ground cover developed, erosion rates decelerated quite rapidly until plant and litter cover reached about 60 percent. As ground cover increased beyond 60 percent, sediment production decreased slowly and steadily. He postulated that plant and litter cover must equal or exceed about 60 percent for minimum soil stability. Bailey and Copeland (1961) found no soil loss on sites having a normal stand of vegetation, where as bared or seriously depleted sites have lost up to 17 tons of soil per acre from one storm. They recommended 65 percent of the soil be covered by vegetation and litter to prevent accelerated erosion. Packer (1951 and 1963) indicates 70 percent of the ground should be covered by plants or litter for adequate control of erosion.

Vegetation-type - As with infiltration, erosion may differ from one vegetation type to another. Copeland (1969) states that soils developed beneath a grass cover have the greatest potential erodibility, while those beneath fir forests are the least erodible.

Shrub-grass and grassland conversion - Rosa and Tigerman (1951) reported on sediment yields from the Sevier Lake watershed and along the Wasatch Front during 1941 to 1947. Sediment yield from sagebrush sites with good vegetal cover was about one-third that from sagebrush sites in fair condition. Sites in poor condition produced sediment about three times greater and bare condition sites produced sediment from five to twelve times greater than sites in fair condition. Rich (1961), and Rowe and Reimann (1961) found erosion to decrease on watersheds coverted from brush to grass cover. Gifford (1972) studied sediment production on plowed big sagebrush sites in southern Idaho. He found sediment rates generally increased following plowing but were variable. Jager (1972) found sediment production three years after treatment to be higher on sites drilled with the modified rangeland drill than those drilled with standard rangeland drill. Meeuwig (1965) studied the effect of seeding a subalpine range in central Utah to grass and found seeding did not significantly affect soil stability.

Pinyon-juniper woodland conversion - Brown (1970) reports the results of a pilot study on Beaver Creek watershed which has shown no change in sediment yield following removal of Utah juniper. Williams, et al. (1969), and Gifford, et al. (1970) indicate that pinyon-juniper conversion to grass does not necessarily increase or decrease sediment yields.

Bare ground - Usually as bare ground increases sediment production increases (Jager, 1972; Bailey and Copeland, 1961; and Packer, 1951 and 1963). Branson and Owen (1970) studied sediment yield in western Colorado and found percent bare ground and relief ratio to explain 74 percent of the variation in sediment production.

Rock cover - Rock cover, like plant and litter cover, is important in dissipating raindrop energy which minimizes soil displacement by raindrops. However, Haupt (1967) concluded that exposed rock accelerates erosion by concentrating flow in surface openings between rocks.

Soil Factors

Texture - Doty and Carter (1965) found the percent sand, silt and clay varied with the rate of soil movement. Percent of clay-sized particles in the runoff was usually high at the beginning of the runoff event, and decreased as soil-loss rate increased. Percent of silt-sized particles was usually low at the beginning of a runoff event and increased as the erosion rate increased. Swanson and Dedrick (1967) observed soil material removed by runoff water was finer textured than original soil surface irrespective of surface slope. However, coarser soil particles were carried from the steeper slopes. Jager (1972) found sediment production to decrease as sand content of the soil surface inch increased. Meeuwig (1971b), studying soil stability on high-elevation rangeland found: (1) clay to be more erodible than sand, if organic matter is low, (2) erodibility of sand tends to increase with increasing organic matter, especially if the soil contains less than 10 percent clay, and (3) if the organic matter content is high, sand can be more erodible than clay. The erodibility of sands high in organic matter are attributed to water repellency. Organic coatings on sand-sized particles may reduce the forces of attraction between particles to such an extent that they repel one another and increase their erodibility.

Organic matter and soil aggregates - In general, as organic matter increases soil aggregates increase. The amount and size of aggregates are important in determining how susceptible to erosion a soil will be. The size is also important in determining the dimensions of the pore space in a soil. The exception to this rule is the sandy soils high in organic matter (Meeuwig, 1971b). Rose (1966) summarized Emerson and Dettman's (1955) model of micro-structure. The model expresses possible ways and mechanisms whereby individual quartz and clay domain particles can be joined together into micro-aggregates. The model proposes that organic matter stabilizes the structure primarily by strengthening the bonds between clay domains and between quartz particles and domains. Meeuwig (1970b) found organic matter to be negatively related to sediment production and an important parameter in predicting erosion, and that well-aggregated soils tend to have low bulk densities and also tend to resist erosion (Meeuwig, 1970a). Farmer and Van Haveren (1971) considered percent of particles and aggregates between 61 and 2,000 microns and the percent of particles and aggregates greater than 2 mm the most important soil variables affecting soil erosion by overland flow.

Bulk density - As illustrated by Meeuwig (1970a) low bulk density usually indicates a well-aggregated soil that is resistant to erosion. Packer (1963) found soil erosion in the Gallatin elk winter range to increase rapidly as the bulk density increased above 1.04 g/cc. The bulk density of soils that develop a vesicular porosity near the surface will decrease with an increase of vesicular porosity. This type of porosity is associated with a very unstable soil structure.

Moisture - Some soils are more erodible when wet and some are more erodible when dry (Meeuwig, 1970a). Jager (1972) found sediment production to vary significantly with plot moisture condition. Sediment was greater from wet soils than from dry soils. Soils that are more erodible when wet are usually characterized by unstable structure. The soils reach saturation quicker when wet and, due to weak aggregation, disintegrate into component particles or into very small aggregates (Rose, 1966).

Particle roughness - Budenzer, Meyer and Nonke (1966), studying the effect of particle roughness on soil erosion found for small particles, erosion rate to increase as the particle roughness increased. However, for larger particles (around 525 microns) there was no major effect of particle roughness on erosion.

Precipitation

Raindrop impact is commonly the most powerful cause of disrupting soil aggregates into their component particles. Rainfall energy is expended in detatching soil particles, transporting them by splash, and increasing runoff turbulence (Rose, 1966; Smith and Wischmeier, 1957; Meyer and Monke, 1965). Packer (1963) noticed that erosion increased with increased intensity of rainfall. Doty and Carter (1965) found peak erosion rates to occur at about the same time as the peak runoff rate which was shortly after the maximum rainfall intensity.

Topography

Slope - Meyer and Monke (1965) studying the mechanics of soil erosion by rainfall and overland flow found runoff erosion to increase rapidly with increasing slope steepness and length, except on gentle slopes and short lengths where essentially no erosion occurred. Budenzer et al. (1966) found sheet erosion prevalent on short gentle slopes, rilling most intense at intermediate slopes. Meeuwig (1970a, 1970b) found percent slope to be positively correlated with erosion and an important variable in predicting erosion rates. Smith and Wischmeier (1957) found percent slope and length of slope to be important parameters affecting soil loss.

Aspect and elevation - Copeland (1969) states that potential erodibility is about 1.3 times greater on west-facing than on east-facing exposures. He also notes that elevation differences influence erodibility, i.e., soils derived from granodiorites at high elevations are potentially about twice as erodible as those at lower elevations. He failed to mention the soil and vegetation difference found on different aspects and at different elevations.

STUDY SITES

Study sites representing different plant communities and/or soils are located in five watersheds in central and eastern Nevada (Figure 1). Climate of these basins is semiarid. Vegetation is represented by the pinyon-juniper, northern desert shrub and salt desert shrub zone. Soils are Aridisols, Mollisols or Entisols. Details for each watershed and study site are as follows:

Duckwater Watershed - This watershed is located about 30 airline miles south and east of Eureka, Nevada, mostly in White Pine County. The basin is in the Bureau of Land Management's Ely District, and consists of approximately 100 square miles of public domain.

Annual precipitation for a three-year period ranged from 7.8 to 13.7 inches. Most of the precipitation comes during the winter months as snow. Approximate temperature at the lower elevations of the basin ranges from a low of —34°F to a high of 99°F with a mean annual temperature of 43°F.

The watershed is in the Pancake Range at the north end of Railroad Valley. Geology of the mountains is diverse but consists mainly of volcanics and sedimentaries, i.e., tuff, basalt, andesites, and limestone. About 40 percent of the watershed is mountainous, 55 percent sloping alluvial fans and 5 percent floodplains. Elevation of the highest peak is around 7,300 feet and the basin outlet is approximately 5,800 feet. Relief between the mountains and adjoining alluvial fans rarely exceeds 1,400 feet.

Dominant overstory vegetation is black sagebrush [*Artemisis nova* (a. Nels.) Ward), big sagebrush [*Artemisia tridentata* Nutt), shadscale [*Artiplex confertifolia* (Torr. & Frem.) Wats.), winterfat [*Eurotia lanata* (Pursh) Moq.), yellow-brush [*Chrysothamnus viscidflorus* (Hook.) Nutt.) Utah juniper [*Juniperus osteosperma* (Torr.) Little) and/or single leaf pinyou [*Pinus monophylla* Torr. & Frem.). Needle-and-thread [*Stipa comata* Trin & Rupr.), beardless bluebunch wheatgrass [*Agropyron inerme* (Scribn. and Smith) Rybd.) and scarlet globemallow [*Sphaeralcea coccinea* (Pursh) Rybd.) are frequent in the understory.

Soils are mostly Aridisols and Entisols, i.e.,, Torrifluvents, Durorthids, Hapargids, Durargids, and Natrargids. Generally, the Torrifluvents and Haplargids occur on the floodplains and Durargids on the mountains.

Water in the basin flows briefly in ephemeral streams resulting from snow melt or thunderstorms. One spring is found in the watershed and a few man-made ponds trap water for livestock use. Drainage is south to Railroad Valley.

Livestock use is mainly sheep during the winter months with a few cows using the area in spring and summer (Blackburn, Tueller and Eckert, 1968; Summerfield and Peterson, 1971).

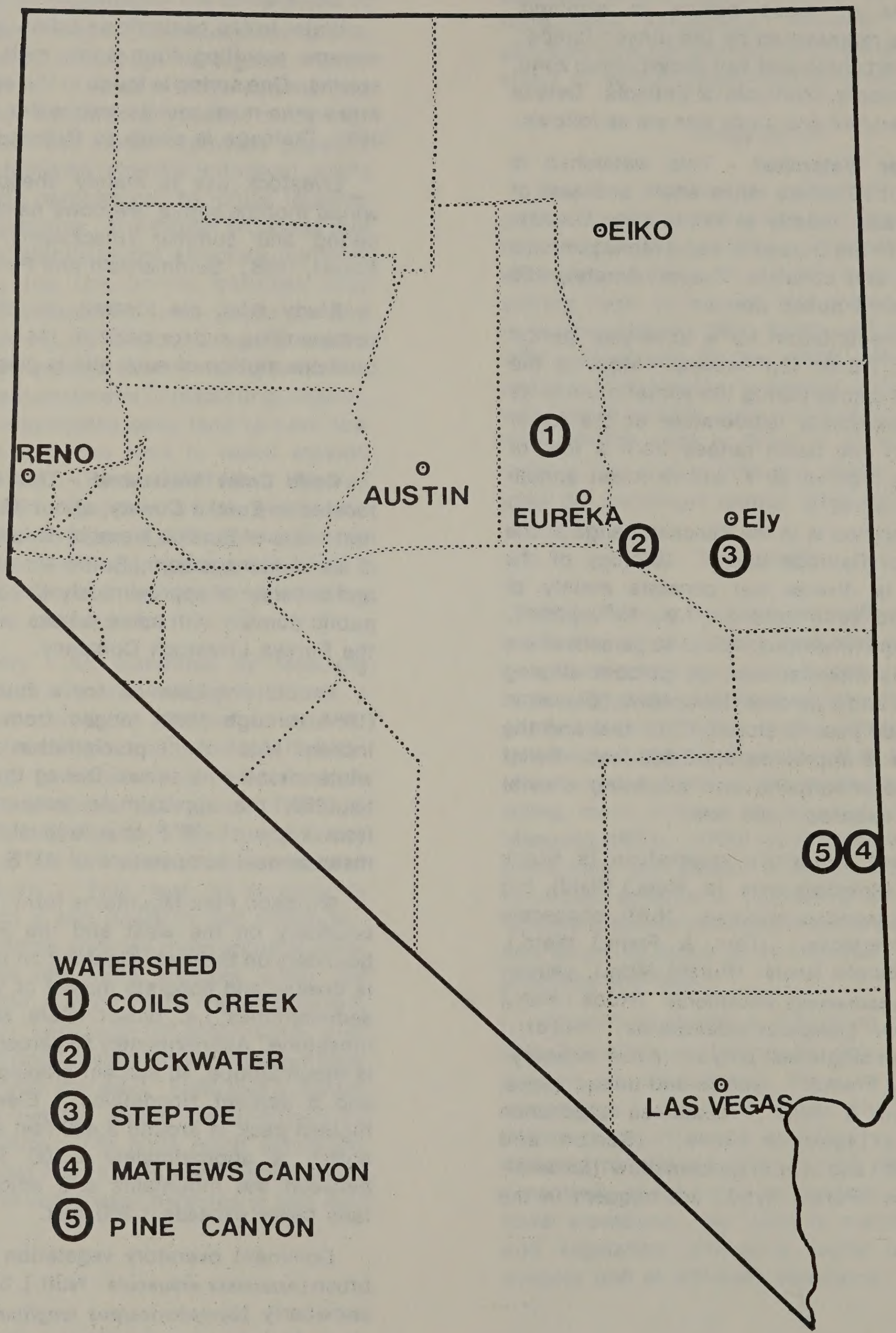
Study sites are located on different plant communities and/or soils in the watershed. A brief description of each site is given in Table 1.

Coils Creek Watershed - This watershed is located in Eureka County, about 32 airline miles northwest of Eureka, Nevada. It is in the Bureau of Land Management, Battle Mountain District, and consists of approximately 48 square miles of public domain with some private land owned by the Eureka Livestock Company.

Annual precipitation for a four-year period (1964 through 1968) ranged from 8.8 to 14.8 inches. Most of the precipitation comes during winter months as snow. During the period 1880 to 1967, the approximate temperature ranged from a low of -26°F to a high of 110°F with a mean annual temperature of 47°F.

Simpson Park Mountains form the watershed boundary on the west and the Red Hills the boundary on the east. Geology on the mountains is diverse and consists mainly of volcanics and sedimentaries, i.e., basalt, shale, sandstone and limestone. Approximately 55 percent of the basin is mountainous, 40 percent sloping alluvial fans and 5 percent floodplains. Elevation of the highest peak is around 8,400 feet and the basin outlet is approximately 6,500 feet. Relief between the mountains and adjoining alluvial fans rarely exceeds 1,900 feet.

Dominant overstory vegetation is low sagebrush [*Artemisia arbuscula* Nutt.], big sagebrush, snowberry [*Symphoricarpos longiflorus* Gray], single leaf pinyon and/or Utah juniper. Sandberg bluegrass [*Poa secunda* Presi.], Idaho fescue



EIKO
RENO
AUSTIN
EUREKA
Ely
LAS VEGAS
WATERSHED
1 COILS CREEK
2 DUCKWATER
3 STEPTOE
4 MATHEWS CANYON
5 PINE CANYON

Table 1. Duckwater Watershed study site descriptions.

Site No.	Plant Community and Symbol	Physiographic Position	Soil Family	Brief Soil Description	Ground Cover	
1	Artemisia nova (Arno)	Crest of broadly rounded dissected old alluvial fan. Slope 4% to the south.	Xerollic Durargid, coarse-loamy, mixed, frigid	Dune interspace areas have a 4.5-inch thick weak medium platy, sandy loam ochric epipedon with many very fine vesicular pores. Coppice dunes have a 5.5-inch thick weak fine granular, sandy loam ochric epipedon with few very fine vesicular pores in the surface 1/4 inch. Both epipedons are over a weak fine subangular blocky, sandy clay loam argillic horizon. There is an indurated duripan 11 inches from the soil surface.	Plant Litter Rock Bare ground	35% 36% 28% 35%
2	Artemisia nova/ Atriplex confertifolia (Arno/Atco)	Crest of dissected alluvial fans. Slope 4% to the west.	Entic Durorthid, coarse-loamy, mixed, frigid	Dune interspace areas have a 4- inch thick moderate fine platy, gravelly sandy loam ochric epipedon with many very fine and common fine vesicular pores. Coppice dunes have a 5.5-inch thick weak fine granular, gravelly sandy loam ochric epipedon with few very fine vesicular pores. Both epipedons occur over a massive, gravelly fine sandy loam cambic horizon. An indurated duripan is at 12 inches from the surface.	Plant Litter Rock Bare ground	31% 51% 25% 21%
3	Artemisia tridentata (Artr)	Smooth alluvial fan. Slope 3% to the east.	Haplic Durargid, fine-loamy, mixed, frigid	Dune interspace areas have a 2-inch thick strong fine platy, clay loam ochric epipedon with many very fine and fine vesicular pores. Coppice dunes have a 5-inch thick weak medium platy, clay loam ochric epipedon. Both epipedons occur over a moderate medium subangular blocky, clay argillic horizon. A weakly cemented duripan occurs at 17 inches.	Plant Litter Rock Bare ground	25% 33% 27% 37%

Table 1. Duckwater Watershed study site descriptions (Cont'd).

Site No.	Plant Community and Symbol	Physiographic Position	Soil Family	Brief Soil Description	Ground Cover	
4	Artemisia tridentata/Chrysothamnus viscidiflorus (Artr/Chvi)	Drainage way flood plain. Slope 2% to the south.	Duric Hap argid, fine-loamy, mixed, frigid	Dune interspace areas have a 5-inch thick weak medium platy, sandy loam ochric epipedon. Coppice dunes have a 6-inch weak medium granular, sandy loam ochric epipedon. Both epipedons occur over a weak medium subangular blocky, sandy clay loam argillic horizon.	Plant Litter Rock Bare ground	38% 52% 4% 42%
5	Atriplex confertifolia (Atco)	Smooth alluvial fan. Slope 4% to the east	Typic Natragid, fine, montmorillonitic, frigid	Dune interspace areas have a 4-inch thick strong fine platy, sandy loam ochric epipedon. Coppice dunes have a 5-inch weak fine platy, sandy loam ochric epipedon. Both epipedons occur over a strong medium angular blocky, clay natric horizon.	Plant Litter Rock Bare ground	39% 35% 8% 55%
6	Atriplex confertifolia/Eurotia lanata (Atco/Eula)	Smooth alluvial fan. Slope 4% to the west.	Entic Durorthid, coarse-loamy, mixed, frigid	Dune interspace areas have a 2-inch thick strong fine platy, sandy loam ochric epipedon with many fine, vesicular pores. Coppice dunes have a 3-inch thick weak fine platy, sandy loam ochric epipedon. Both epipedons occur over a weak medium subangular blocky, sandy loam cambic horizon. A weakly cemented duripan occurs at 15 inches.	Plant Litter Rock Bare ground	37% 44% 11% 40%

Table 1. Duckwater Watershed study site descriptions (Cont'd).

Site No.	Plant Community and Symbol	Physiographic Position	Soil Family	Brief Soil Description	Ground Cover	
7	Eurotia lanata (Eula)	Modern drainageway floodplain. Slope 1% to the south.	Typic Torrifluvent, coarse-loamy, mixed, mesic	Dune interspace areas have a 6.5-inch thick ochric epipedon of which the upper 2.5 inches is characterized by a strong medium platy, loam A11 horizon with many very fine and fine vesicular pores. Coppice dunes have a 7-inch thick ochric epipedon of which the upper 3 inches is characterized by a weak medium platy, loam A11 horizon with few fine vesicular pores. Both epipedons are over a C1 horizon.	Plant Litter Rock Bare ground	8% 45% 1% 52%
8	Juniperus osteosperma (Juos)	Slope of broadly rounded dissected old alluvial fan. Slope 10% to the southeast.	Haplic Durargid, fine-loamy, mixed, frigid	Dune interspace areas are characterized by a 1.5-inch massive, gravelly sandy loam ochric epipedon with common fine vesicular pores. Coppice dunes have a 2-inch thick duff layer over a 3-inch thick weak fine granular, gravelly sandy loam ochric epipedon. Both epipedons occur over a weak fine subangular, loam argillic horizon. A strongly cemented duripan occurs at 12 inches from the surface.	Plant Litter Rock Bare ground	0% 57% 20% 23%
9	Pinus monophylla/Juniperus osteosperma (Pimo/Juos)	Lower pediment slope at margin of mountain. Slope 6% southeast.	Xerollic Haplargid, fine-loamy, mixed, frigid	Dune interspace areas have a 5-inch thick ochric epipedon. The 2-inch thick single grain, loamy sand A11 horizon is without pores, however, the 3-inch weak fine granular, sandy loam A12 horizon has few fine vesicular and tubular pores. Coppice dunes have a 4-inch thick duff layer over a 6-inch thick weak fine granular, loamy sand ochric epipedon. Both epipedons are over a moderate fine subangular blocky, sandy clay loam argillic horizon.	Plant Litter Rock Bare ground	0% 58% 24% 18%

[*Festuca idahoensis* Elmer.], bluebunch wheatgrass [*Agropyron spicatum* (Pursh) Scribn. & Smith], cheatgrass [*Bromus tectorum* L.], squirreltail [*Sitanion hystrix* (Nutt) J.G. Smith], wooly wyethia [*Wyethia mollis* Gray], arrowleaf balsamroot [*Balsamorhiza sagittata* (pursh.) Nutt.), and diffused phlox [*Phlox diffusa* Benth.] are frequent in the understory.

Soils are Entisols, Aridisols, or Mollisols, i.e., Torriorthents, Camborthids, Haplargids, Durargids, Haplaquolls, Haplustolls, Haploxerolls, Durixerolls, and Argixerolls. Generally, the Haplaquolls and Haplustolls occur on the floodplains; Camborthids, Haplargids and Durargids on the alluvial fans; and Torriorthents, Haplargids, Hapioxerolls, Durixerolls and Argixerolls on the Mountains.

Water in the basin flows briefly in ephemeral streams from snow melt or thunderstorms. However, a number of perennial springs are found in the watershed. Drainage is south to Kobeh Valley.

At the present time the Eureka Livestock Company runs approximately 2,000 sheep and 400 cows in the basin (Blackburn, Eckert and Tueller, 1969a).

Study sites are located on different plant communities and/or soils in the watershed. A brief description of each site is given in Table 2.

Steptoe Watershed - This watershed is located about 24 airline miles southeast of Ely, Nevada. It is in the Bureau of Land Management's Ely District, and consists of approximately 45 square miles of public domain.

Annual precipitation is 12 inches. Most of the precipitation comes during the winter months as snow. Approximate temperature at the lower elevations of the basin ranges from a low of -26°F to a high of 97°F, with a mean annual temperature of 44.3°F.

The basin is in the Schell Creek Mountain range at the south end of Steptoe Valley. Geology of the mountains is mainly sedimentary, i.e., limestone. About 67 percent of the watershed is mountainous, 30 percent sloping alluvial fans and 3 percent floodplains. Elevation of the highest peak is around 9,081 feet and the basin outlet is approximately 7,100 feet. Relief between the mountains and adjoining alluvial fans rarely exceeds 1,000 feet.

Dominant overstory vegetation is mainly big and low sagebrush, curlleaf mountain mahogany [*Cerocarpus ledifolius* Nutt.], bitterbrush [*Purshia tridentata* (Pursh.) DC),single leaf pinyon and/or Utah juniper.

Bluebunch wheatgrass, Sandberg bluegrass, squirreltail, and crested wheatgrass [*Agropyron desertorum* (Fisch) Schult) are frequent in the understory.

Two plant communities have been plowed and seeded to crested wheatgrass. Nine hundred and twenty-five acres of *Artemisia tridentata* community in 1965 was plowed and drilled using five pounds of crested wheatgrass seed per acre. This new community, *Agropyron desertorum*, was established six years prior to this study. In 1967, 1,300 acres of the *Artemisia tridentata/ - Agropyron spicatum* community was plowed and drilled using 7.7 pounds of crested wheatgrass per acre. This new community, *Agropyron desertorum* (high), was established five years prior to this study.

Soils are Aridisols or Millisols, i.e., Camborthids, Haplargids, Durargids, and Argixerolls. Generally, Cambothids occur on the floodplains; Haplargids, Durargids and Argixerolls on the alluvial fans; and Camborthids, Haplargids and Argixerolls on the mountains.

Water in the basin flows briefly in ephemeral streams from snow melt or thunderstorms. A few perennial springs are found in the basin. Drainage is north to Steptoe Valley.

Grazing use is mainly from cattle in spring, summer and fall.

A brief study site description is given in Table 3. A more detailed description is given by Heinze, Eckert and Tueller, (1966).

Table 2. Coils Creek Watershed study site descriptions.

Site No.	Plant Community and Symbol	Physiographic Position	Soil Family	Brief Soil Description	Ground Cover
10	Artemisia arbuscula/Poa secunda (Low) (Arar/Pose low)	Crest of broadly rounded dissected old alluvial fan. Slope 3% to the east.	Abruptic Xerollic Durargid, very fine, montmorillonitic, frigid	Dune interspace areas have a 3-inch thick strong fine platy, clay loam ochric epipedone with many very fine and fine vesicular pores. Coppice dunes have a 7-inch moderate fine platy, clay loam ochric epipedon with few very fine vesicular pores. Both epipedons abruptly change to a moderate fine subangular blocky, clay argillic horizon. Indurated duripan occurs at 23 inches.	Plant 67% Litter 62% Rock 8% Bare ground 25%
11	Artemisia arbuscula/Poa secunda (Arar/Pose)	Convex slope of moderately high mountain. Slope 13% to the northwest.	Xerollic Haplargid, loamy-skeletal, mixed, frigid, shallow	Dune interspace areas have a 5-inch thick weak fine granular, sandy loamy ochric epipedon. Coppice dunes have a 7-inch thick weak fine granular, sand loam ochric epipedon. Both epipedons occur over a moderate fine subangular blocky, gravelly clay loam argillic horizon. Paralithic contact occurs at 20 inches from the surface.	Plant 46% Litter 58% Rock 19% Bare ground 22%
12	Artemisia tridentata/Agropyron spicatum/Balsamorhiza sagittata (Artr/Agsp/Basa)	Crestof moderately high mountain. Slope 6% to the west.	Xerollic Haplargid, loamy-skeletal, mixed, frigid	Dune interspace areas have a 6-inch thick weak fine granular, gravelly very fine sandy loam ochric epipedon with few medium insterstitial tubular pores. Coppice dunes have a 9-inch thick weak fine granular, gravelly very fine sandy loam ochric epipedon with few medium insterstitial tubular pores. Both epipedons occur over a medium moderate subangular blocky, gravelly clay loam argillic horizon.	Plant 65% Litter 58% Rock 19% Bare ground 22%

Table 2. Coils Creek Watershed study site descriptions (Cont'd).

Site No.	Plant Community and Symbol	Physiographic Position	Soil Family	Brief Soil Description	Ground Cover
13	Artemisia tridentata/Poa secunda/Phlox diffusa (Artr/Pose/Phdi)	Crest of broadly rounded dissected old alluvial fan. Slope 1% to the east.	Xerollic Durargid, fine, montmorillonitic, frigid	Dune interspace areas have a 3-inch thick moderate fine platy, very fine sandy loam ochric epipedon with many very fine and few fine vesicular pores. Coppice dunes have a 5-inch weak fine platy, very fine sandy loam ochric epipedon with few very fine vesicular pores. Both epipedons occur over a moderate fine subangular blocky clay argillic horizon. Indurated duripan occurs at 23 inches.	Plant 68% Litter 69% Rock 3% Bare ground 27%
14	Pinus monophylla/ Juniperus osteosperma /Artemisia arbuscula/ Poa secunda (Pimo/Juos/ Arar/Pose)	Crest of moderately high mountain. Slope 3% to the west.	Typic Torriorthen, loamy-skeletal, mixed, frigid, shallow	Dune interspace areas have a 1-inch thick weak fine granular, gravelly sandy loam ochric epipedon. Coppice dunes have a 3-inch thick weak fine granular, gravelly sandy loam ochric epipedon. Both epipedons occur over a massive, gravelly sandy loam C1 horizon. Shale bed rock occurs at 8 inches.	Plant 46% Litter 35% Rock 53% Bare ground 10%
15	Symphoricarpos longiflorus/ Artemisia tridentata/ Agropyron spicatum/ Wyethia mollis (Sylo/Artr/Agsp/ Wymo)	Concave slope of moderately high mountain. Slope 6% to the north.	Pachic Argixeroll, clayey-skeletal, mixed, frigid	Dune interspace areas have a 10-inch thick weak fine granular, gravelly sandy loam mollic epipedon, with few fine and common medium tubular pores. Coppice dunes have a 13-inch thick weak fine granular, gravelly sandy loam mollic epipedon, with few fine and common medium tubular pores. Both epipedons occur over a strong fine subangular blocky, gravelly clay argillic horizon.	Plant 98% Litter 93% Rock 0% Bare ground 6%

Table 3. Steptoe Watershed study site descriptions.

Site No.	Plant Community and Symbol	Physiographic Position	Soil Family	Brief Soil Description	Ground Cover	
16	Artemisia tridentata (Artr)	Modern drainageway floodplain. Slope 2% to the northwest.	Durixerollic Camborthid, coarse loamy, mixed, frigid	Dune interspace areas have a 5-inch thick massive, very fine sandyloam ochric epipedon. Coppice dunes have a 6-inch thick weak fine granular, very fine sandy loam ochric epipedon. Both epipedons occur over a massive, loamy cambic horizon.	Plant Litter Rock Bare ground	74% 93% 0% 4%
17	Agropyron desertorum (Low) (Agde low)	Modern drainageway floodplain. Slope 2% to the northwest.	Durixerollic Camborthid, coarse loamy, mixed, frigid	This is the same soil as the above site, except it has been plowed and seeded to *Agropyron desertorum*. There is a 6-inch thick weak fine granular, very fine sandy loam ochric epipedon over a massive, loamy cambic horizon.	Plant Litter Rock Bare ground	46% 61% 0% 29%
18	Artemisia tridentata/Agropyron spicatum (Artr/Agsp)	Crest of broadly rounded dissected old alluvial fan. Slope 4% to the northeast.	Haploxerollic Durargid, loamy-skeletal, mixed, frigid	Dune interspace areas have a 4-inch thick massive, gravelly sandy loam ochric epipedon with few fine vesicular pores in the surface inch. Coppice dunes have a 5-inch thick weak fine granular, gravelly sandy loam ochric epipedon. Both epipedons occur over a subangular blocky, gravelly clay loam argillic horizon.	Plant Litter Rock Bare ground	63% 43% 14% 28%

Table 3. Steptoe Watershed study site descriptions (Cont'd).

Site No.	Plant Community and Symbol	Physiographic Position	Soil Family	Brief Soil Description	Ground Cover	
19	Agropyron desertorum (High) (Agde)	Crest of broadly rounded old alluvial fan. Slope 4% to the northeast.	Haploxerollic Durargid, loamy-skeletal, mixed, frigid	This is the same soil as the former site, except it has been plowed and seeded to *Agropyron desertorum*. There is a 5.5-inch thick weak fine granular, gravelly sandy loam ochric epipedon over a moderate fine subangular blocky, gravelly clay loam argillic horizon.	Plant Litter Rock Bare ground	66% 47% 8% 29%
20	Artemisia tridentata/Purshia tridentata/ Agropyron spicatum (Artr/Putr/ Agsp)	Crest of broadly rounded dissected old alluvial fan. Slope 6% to the north.	Durix Argixeroll, loamy-skeletal, mixed, frigid	Dune interspace areas have a 3-inch thick weak fine granular, very gravelly loam mollic epipedon. Coppice dunes have a 5-inch thick weak fine granular, very gravelly loam mollic epipedon. Both epipedons occur over a moderate medium subangular blocky, very gravelly clay loam argillic horizon.	Plant Litter Rock Bare ground	86% 57% 9% 25%
21	Pinus monophylla/Juniperus osteosperma (Pimo/Juos)	Slope of moderately high mountain. Slope 12% to the southwest.	Xerollic Camborthid, loamy-skeletal, mixed, frigid, shallow	Dune interspace areas have a 4-inch thick massive, gravelly sandy loam ochric epipedon with few fine vesicular pores. Coppice dunes have a 5-inch thick weak fine granular, gravelly sandy loam ochric epipedon. Both epipedons occur over a massive, gravelly loam cambic horizon.	Plant Litter Rock Bare ground	32% 16% 45% 34%

Pine and Mathews Canyon Watersheds - These watersheds are located about 18 airline miles southeast of Caliente, Nevada, mostly within the Barclay Summer Allotment of the Bureau of Land Management, Las Vegas District. The two basins include approximately 66 square miles.

Annual precipitation for a four-year period ranged from 11.9 to 21.8 inches, which was one below and three above average precipitation years. Most of the moisture comes during the winter months as snow or during late summer as rain. Approximate temperature of the basin ranged from a low of 0°F to a high of 101°F with a mean temperature around 50°F.

These watersheds lie within the southern part of the Basin and Range Physiographic Province. Geology of the mountains is mainly volcanic and old lake bed sediments, i.e., andesite, tuff, ignibrite, tuffaceous clay, sand and silt. About 35 percent of the watershed in mountainous, 60 percent sloping alluvial fans and 5 percent floodplains. Elevation of the highest peak is around 6,700 feet and the basin outlets are approximately 5,600 feet. Relief between mountains and adjoining alluvial fans rarely exceed 900 feet.

Dominant overstory vegetation is mainly black and big sagebrush, rubber rabbitbrush [*Chrysothamnus nauseous* (Pall.) Britton), single leaf pinyon and/or Utah juniper, serviceberry [*Amelanchier alnifolia* M.E. Jones) and gambel oak ([*Quercus gambeli* Nutt.). Crested wheatgrass, intermediate wheatgrass *Agropyron intermedium* (Host) Beauv.), blue grama [*Bouteloua gracilis* (H.B.K.) Lag. ex Steud), Sandberg bluegrass, squirreltail and cheatgrass are frequent in the understory.

Three plant communities have received some kind of range treatment. Two hundred and fifty-eight acres of *Artemisia tridentata/Chrysothamnus nauseosus* community in 1954 was treated once using a Hogan Brush Drag (two rails followed by 5-foot pipe drags) and then drilled using 8 pounds of crested wheatgrass seed per acre. This new community, [*Artemisia tridentata/Agropyron desertorum* was established 17 years prior to this study. In 1969, 3,500 acres of *Pinus monophylla/Juniperus osteosperma/Artemisia nova/Amelanchiau alnifolla* community was chained using 90 pound chain links. The area was then aerial seeded at a rate of 10 pounds of seed per acre and then cross chained. This new community *Artemisia nova/Agropyron intermedium*, was established three years prior to this study. Eleven hundred acres of the *Juniperus osteosperma/Artemisia tridentata/Sitanion hystrix* community in 1961 was aerial seeded using 10 pounds per acre of crested wheatgrass seed, then it was chained in one direction using 40 pound links. This new community, *Juniperus osteosperma/Agropyron desertorum*, was established 11 years prior to this study.

Soils are mostly Aridisols and Mollisols with a few Entisols, i.e., Torriorthents, Durargids, Haplargids, Argixerolls, and Haploxerolls. Generally, Torriorthents occur on the floodplains Durargids, Haplargids and Argixerolls on the alluvial fans; Argixerolls and Haploxerolls on the mountains. Water in the two basins flows briefly in ephemeral streams from snow melt or thunderstorms. Drainage is to Meadow Valley Wash and the Colorado River. A number of perennial springs, man-made ponds and wells are found throughout the watersheds.

The watersheds are used primarily for cattle summer range (May 16 to September 30). Sixteen cattle operators have grazing privileges within the Allotment. Cattle are trucked or trailed from the adjoining winter range and in the fall they are moved to private property or placed back on winter range. The basins, however, are part of a critical deer winter range for herds summering in Utah and adjacent Nevada areas.

A brief study site description is given in Table 4. A more detailed description is given by Blackburn, Tueller and Eckert (1969b).

Table 4. Pine and Mathews Canyon Watersheds study site descriptions.

Site No.	Plant Community and Symbol	Physiographic Position	Soil Family	Brief Soil Description	Ground Cover	
22	Artemisia tridentata/Chrysothamnus nauseosus (Artr/Chna)	Crest of dissected old alluvial fan. Slope 6% to the north.	Xerollic Haplargid, clayey-skeletal, montmorillonitic, frigid	Dune interspace areas have a 4-inch thick massive, gravelly sandy loam ochric epipedon with very few fine vesicular pores. Coppice dunes have a 5-inch thick weak fine granular, gravelly sandy loam ochric epipedon. Both epipedons occur over a medium strong subangular blocky, gravelly clay argillic horizon.	Plant Litter Rock Bare ground	32% 33% 8% 49%
23	Artemisia tridentata/Agropyron desertorum (Artr/Agde)	Crest of dissected old alluvial fan. Slope 6% to the north.	Xerollic Haplargid, clayey -skeletal, montmorillonitic, frigid	This is the same soil as the former site except it has been plowed and seeded to *Agropyron desertorum*. Little difference exists between coppice dunes and dune interspace areas. There is a 4-inch thick weak medium granular, gravelly sandy loam ochric epipedon over a medium strong subangular blocky, gravelly clay argillic horizon.	Plant Litter Rock Bare ground	53% 45% 24% 25%
24	Juniperus osteosperma (Juos)	Crest of broadly rounded dissected old alluvial fan. Slope 2% to the northwest.	Xerollic Haplargid, fine, montmorillonitic, frigid	Dune interspace areas have a 3-inch thick weak medium platy, gravelly clay loam ochric epipedon with common very fine and fine vesicular pores. Coppice dunes have a 5-inch thick weak medium granular, gravelly sandy loam ochric epipedon. Both epipedons occur over a strong medium subangular blocky, gravelly clay argillic horizon.	Plant Litter Rock Bare ground	0% 51% 10% 39%

Table 4. Pine and Mathews Canyon Watersheds study site descriptions (Cont'd).

Site No.	Plant Community and Symbol	Physiographic Position	Soil Family	Brief Soil Description	Ground Cover	
25	Pinus monophylla/ Juniperus osteo-sperma/Artemisia nova /Amelanchier alnifolia (Pimo/Juos/Arno/ Amal)	Crest of broadly rounded dissected old alluvial fan. Slope 8% to the southwest.	Xerollic Haplargid, clayey-skeletal, montmorillonitic, frigid	Dune interspace areas have a 3-inch thick massive, gravelly sandy loam ochric epipedon with common fine and medium vesicular pores. Coppice dunes have a 4-inch thick massive, gravelly sandy loam ochric epipedon. Both epipedons occur over a strong medium subangular blocky, gravelly clay argillic horizon.	Plant Litter Rock Bare ground	43% 29% 20% 48%
26	Artemisia nova/ Agropyron inter-medium (Arno/Agin)	Crest of broadly rounded dissected old alluvial fan. Slope 8% to the southwest.	Xerollic Haplargid, clayey-skeletal, montmorillonitic, frigid	This is the same soil as the former site, except it has been chained and seeded to *Agropyron intermedium*.	Plant Litter Rock Bare ground	44% 45% 11% 40%
27	Juniper osteo-sperma/Artemisia tridentata/ Sitanion hystrix (Juos/Artr/Sihy)	Crest of dissected old alluvial fan. Slope 2% to the southwest.	Xerollic Haplargid, clayey-skeletal, montmorillonitic, frigid	Dune interspace areas have a 4-inch thick massive, sandy loam ochric epipedon with common fine and medium vesicular pores. Coppice dunes have a 5-inch thick weak fine granular, sandy loam ochric epipedon. Both epipedons occur over a strong medium subangular blocky, gravelly clay argillic horizon.	Plant Litter Rock Bare ground	4% 50% 10% 39%
28	Juniperus osteo-sperma/Agro-pyron desertorum (Juos/Agde)	Crest of dissected old alluvial fan. Slope 2% to the south-east.	Xerollic Haplargid, clayey-skeletal, montomorillonitic, frigid	This is the same soil as the former site except the trees have been chained and site seeded to *Agropyron desertorum*.	Plant Litter Rock Bare ground	56% 60% 3% 32%

METHODS

Twenty-eight study sites were selected within the five watersheds. There were nine sites located within Duckwater Watershed, six sites within Coils Creek Watershed, six sites within Steptoe Watershed, and seven sites within Pine and Mathews Canyon Watersheds. Study sites were selected on their accessibility, repitition over large areas in the Great Basin, and vegetation and soil properties. Each site was located on a typical area of a different plant community and/or soil.

Mean infiltration rates and sediment production for study sites were obtained by including in runoff plots the same percent coppice dune that occurred on the site. However, it was soon obvious that to understand the mean infiltration rates it would be necessary to study coppice dunes and dune interspace areas separately.

In the Great Basin summer thunderstorms usually occur on dry soil, although some occur on soil that is at or near field capacity, thus, the necessity for sampling two moisture conditions. A 3-inch per hour storm was used to simulate the exceptional thunderstorm and to assure site infiltration rate was exceeded. In addition, a 1½-inch per hour storm was used to simulate a more normal thunderstorm intensity.

Soil morphology was examined in considerable detail so that infiltration and sediment data could be tied to soils and extrapolated by soils and/or vegetation.

INFILTRATION

An infiltrometer was designed and built after one described by Chow and Harbaugh (1965) but modified for field use (Figure 2). The following discussion refers to numbers in Figure 2.

The infiltrometer was built on a U.S. Army surplus two-wheel trailer (1). The water supply (2) is a 300-gallon tank where the water is pumped to the elevated 50-gallon tank (3) for gravity flow through filters and flow meters (4, Figure 3) to the water chambers (5). Chambers are suspended from adjustable arms (6). Power source is a large 12 volt battery (7). Runoff plots are of two types, regular 3x3-foot and variable (8, Figure 4). Runoff is collected in a small pail and pumped (9) into a 5-gallon polyethylene bottle (10) where it is weighed (11).

Water chambers are constructed of 4x4-foot, ¼-inch thick plexiglass sheets bolted to angle aluminum. Raindrop-producing tubes are 23 gage stainless steel, ¾-inch long with .01875 inside diameter. Tubes are placed on 1-inch spacings. Adjustable guy wires are used to level the water chambers and these chambers are 7-feet above the soil surface. At this distance simulated drops reach about 72 percent of maximum falling velocity (Chow and Harbaugh, 1965; and Todd, 1970). Water chambers of similar construction have been described by Timko and Skau (1967), and Meeuwig (1971a).

Infiltration was defined for any point in time as the difference between total water applied and total runoff. Two types of runoff plots were used, i.e., regular 3x3-foot and variable. Regular plots were situated so the same mean percent coppice dune that occurred on the site occurred in the plot. Variable plots were located so they contained approximately 100 percent dune interspace area or coppice dune. Variable plots were used only on sites that demonstrated obvious dune interspace and coppice dune differences, and as time permitted. Water was applied to these plots at two rates: (1) one and one-half inches per hour for a duration of one hour, and (2) three inches per hour for one-half hour. Runoff was measured at 5-minute intervals and later converted to infiltration in inches per hour. Tests were made under field conditions when the soil surface was nearly air-dry and approximately 24 hours later when the soil was at or near field capacity. Immediately after the first wetting the plots were covered using a clear polyethylene plastic in order to cut down on evaporation and maintain a uniform soil surface moisture condition.

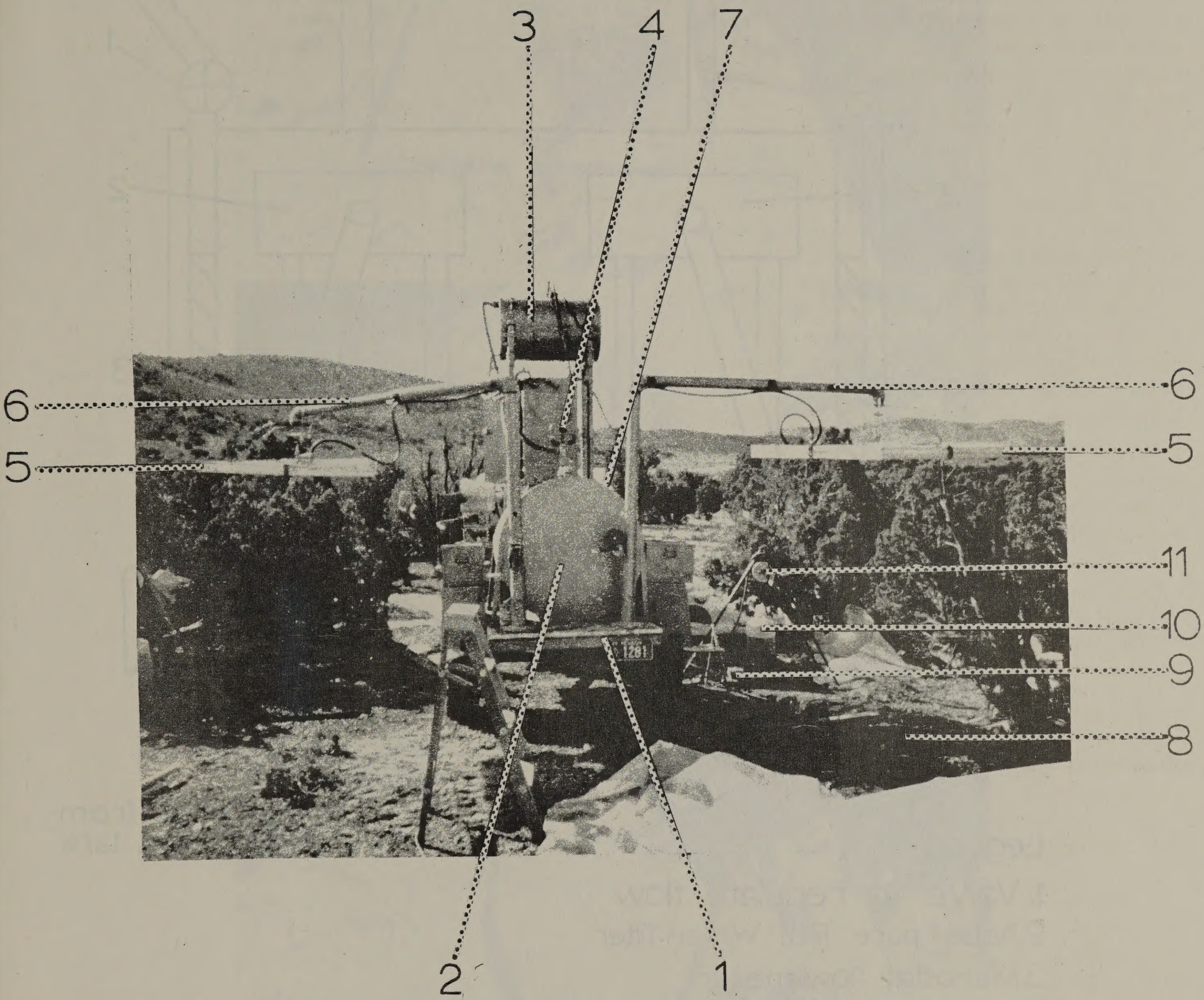


Figure 2. Infiltrometer.

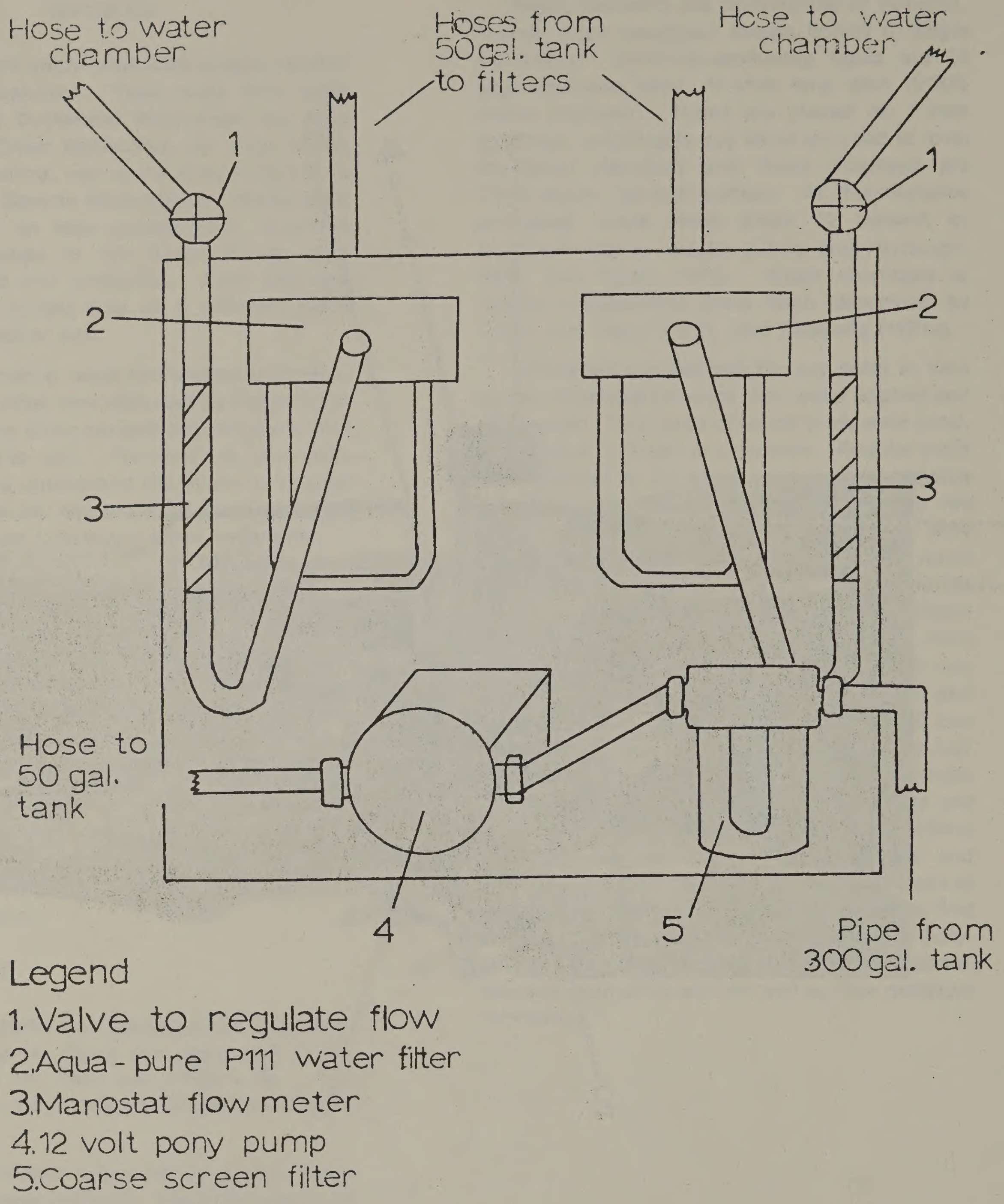


Figure 3. Schematic drawing of control box.

Figure 4. Regular 3 by 3-foot runoff plot (top) and variable runoff plots (middle and bottom).

SEDIMENT PRODUCTION

Sediment production was determined from runoff at the end of the test. After each test, sediment trapped in the collection system was collected along with a 900mi sample of runoff. Suspended sediment was allowed to settle in the laboratory and the water drained off. Samples were then oven-dried, weighed, and converted to sediment in tons per acre.

COVER

Plant cover and composition, litter rock (1/8 to 2 inches in largest dimension), rock (>2 inches in largest diminsion), and bare ground on each plot were measured with a point frame (Levy and Madden, 1933). Two transects of 18 mechanically spaced pins were established on each runoff plot with each about one-third of the distance from the plot edge. For each pin dropped, canopy cover and ground surface characteristics were recorded, thus it was possible to have more than 100 percent total cover. Sampling in this manner allowed for 36 pins per study plot which was probably an under sample.

Coppice dunes within the plots were measured in two directions and the ellipse formula used to compute cover. Dune interspace areas were computed as the complement of coppice dune.

SOILS

A soil-profile description was made at each study site according to the procedures outlined by U.S. Department of Agriculture (1951, 1960). Family-level identifications were made in accordance with the Soil Conservation Service, U.S. Department of Agriculture (1960, 1970). The surface horizon (from the surface to some diagnostic subsurface horizon) was rated from one to five based on structure and vesicular pores. This surface horizon morphological rating is given in Table 5. Likewise, each soil was classified as to hydrologic group (U.S. Department of Agriculture, 1964).

Bulk density and initial soil moisture content was determined using Troxler's model 1401 surface moisture-density gauge. Bulk density was determined for surface 2, 4, and 6-inch depths of dune interspace areas and coppice

TABLE 5
SOIL SURFACE HORIZON MORPHOLOGICAL RATING

RATING	SOIL SURFACE HORIZON MORPHOLOGICAL DESCRIPTION
1	Single grain sandy texture or well aggregated granular-structure without vesicular pores - 1/
2	Granular or massive structure having few - 2/ vesicular pores
3	Massive or weak platy structure having common vesicular pores
4	Moderate platy structure having common vesicular pores, or massive structure having many vesicular pores, or clayey and weakly structured.
5	Strong platy structure having many vesicular pores, or clayey and massive

1/ Granular, approximately spherical with no accommodation of faces to surrounding peds.

Platy, with vertical dimension small with regard to horizontal dimensions; faces accomodate with those of adjacent peds.

Massive, no aggregation.

2/ **Pore Abundance Classes**

Pores	No./Unit* - Area of Surface
Few	1 to 3
Common	4 to 14
Many	More Than 14

* Unit is a square inch for fine, very fine, and micro pores, a square yard for medium and coarse pores.

dunes. Soil moisture before the dry infiltration test was taken concurrent with bulk density readings. To prevent plot disturbance these readings were taken on areas adjacent to plots. In order to obtain soil moisture before the wet run an additional plot was sprinkled, covered with polyethylene plastic, and left for 24 hours before the moisture reading was taken. Particle size distribution of each horizon including surface dune interspace areas and coppice dunes was measured by the hydrometer method (Bouyoucos, 1962). Organic carbon content of each horizon including surface dune interspace areas and coppice dunes was determined by a high-temperature induction furnace (Black, 1965).

PHYSIOGRAPHY

Each study site was classified as to its physiographic placement, i.e., mountain, smooth or dissected alluvial fan or floodplain. Percent slope was obtained from an Abney level, and aspect from an 8-point compass. Surface roughness of each plot was determined using a microrelief meter as described by Kincaid and Williams (1966).

ANALYSES

Data were subjected to three types of statistical analysis. These were: 1) skewness and kurtosis tests on each variable in order to determine normality of data; 2) analysis of variance to compare infiltration rates and sediment production by treatment for each watershed and, finally, 3) multiple regression and correlation analysis to determine which parameters are an important influence on infiltration.

Skewness and kurtosis tests (Snedecor and Cochran, 1971) were applied to the data of each variable in order to determine departure from normality. Four variables showed a significant departure from a normal distribution, these are: sediment for both soil surface moisture conditions, slope and roughness factor (Table 6). Data for these variables were skewed to the right i.e., coefficient of skewness larger than zero. This means that low values are bunched close to the mean and high values extended far above the mean. These four variables also had a high coefficient of kurtosis, that is if the coefficient exceeds three, there is an excess of values near the mean and far from it, with a corresponding depletion of the flanks of the distribution curve. Sediment and roughness factor data logarithmically transformed significantly approached a normal distribution for all treatments except sediment data from plots initially at field capacity (Table 6). Transformed slope data squared also significantly approached a normal distribution.

There were four treatments: two application rates, (1) 1.5 inches per hour for a duration of one hour, and (2) 3 inches per hour for a duration of 30 minutes; two moisture conditions, (3) soil surface horizon initially air dry, and (4) soil surface horizon initially at field capacity. There were six relpications for each treatment except for some sites at Duckwater where eight were used. For all variable plots, six replications were used for dune interspace and six for coppice dunes.

A one-way analysis of variance was used to compare infiltration rates and sediment production by treatment for each watershed and combination of sites from different watersheds. Analyses were conducted on terminal infiltration rates and significant differences were determined by Duncan's New Multiple Range Test (Steel and Torrie, 1960).

Multiple regression and correlation analyses were calculated using a reverse stepwise multiple regression and correlation procedure. This program also computed the simple correlation, mean, standard deviation and standard error of estimate. Dependent and independent variables are listed in Table 7. Variables appearing in multiple regression equations were selected by an F test and the combination of variables having the lowest reasonable standard error of estimate.

Standard partial regression coefficients were also computed for each regression equation in order to determine which X variables are most important in determining Y.

Regression and correlation analyses for infiltration by time interval and terminal rate, and for total sediment production were made by treatment for each watershed. In addition, watersheds were combined for terminal infiltration analysis.

TABLE 6. SKEWNESS AND KURTOSIS COEFFICIENTS, BEFORE AND AFTER TRANSFORMATION, FOR VARIABLES NOT NORMALLY DISTURBED.

Variable	Not Transformed		Transformed		
	Skewness	Kurtosis	Transformation	Skewness	Kurtosis
Sediment					
Soil initially dry	1.59^{ns}	5.94^{ns}	Logarithm	-0.26*	3.18*
Soil initially at field capacity	1.92^{ns}	8.61^{ns}	Logarithm	-0.74^{ns}	3.61*
Roughness factor	2.35^{ns}	9.79^{ns}	Logarithm	0.05*	2.59*
Slope	1.28^{ns}	4.43^{ns}	Squared	0.03*	2.07*

* Significantly approaches a normal distribution at 1% level.
ns Does not significantly approach a normal distribution at 1% level.

Table 7. List of dependent and independent variables used in regression and correlation analyses.

Number	Description	Terms Used in Description
	Application Rate 3 Inches Per Hour	
Y1	Average infiltration rate after 10 minutes, soil surface initially dry	Inches per hour
Y2	" " " " 20 " " " " "	" " "
Y3	" " " " 30 " " " " "	" " "
Y4	Log. total sediment production	Tons per acre
Y5	Average infiltration rate after 10 minutes, soil surface initially at field capacity	Inches per hour
Y6	" " " " 20 " " " " " " "	" " "
Y7	" " " " 30 " " " " " " "	" " "
Y8	Log. total sediment production	Tons per acre
	Application Rate 1 1/2 Inches Per Hour	
Y9	Average infiltration rate after 10 minutes, soil surface initially dry	Inches per hour
Y10	" " " " 20 " " " " "	" " "
Y11	" " " " 30 " " " " "	" " "
Y12	" " " " 60 " " " " "	" " "
Y13	Log. total sediment production	Tons per acre
Y14	Average infiltration rate after 10 minutes, soil surface initially at field capacity	Inches per hour
Y15	" " " " 20 " " " " " " "	" " "
Y16	" " " " 30 " " " " " " "	" " "
Y17	" " " " 60 " " " " " " "	" " "
Y18	Log. total sediment production	Tons per acre

Table 7. List of dependent and independent variables used in regression and correlation analyses (Cont'd)

Number	Description	Terms Used in Description
X 1	Soil bulk density in surface 0 to 2 inches, coppice dune	Grams per cubic centimeter
X 2	" " " " " 0 to 4 " , " "	" " " "
X 3	" " " " " 0 to 2 " , dune interspace	" " " "
X 4	" " " " " 0 to 4 " , " "	" " " "
X 5	" " " " " 0 to 2 " , weighted [(X1)(X9/100)+(X3)(X9/100)]	" " " "
X 6	" " " " " 0 to 4 " , weighted [(X2)(X9/100)+(X4)(X9/100)]	" " " "
X 7	Rock (1/8 to 2 inches in largest dimension)	Percent
X 8	Rock (> 2 inches in largest dimension)	"
X 9	Bare ground	"
X10	Dune interspace	"
X11	Coppice dune	"
X12	Litter	"
X13	Plant cover	"
X14	Slope	"
X15	Roughness factor	Inches squared
X16	Soil surface horizon morphological rating, coppice dune	1 to 5
X17	" " " " " , dune interspace	" " "
X18	" " " " " , weighted [(X16)(X11/100)+(X17)(X10/100)]	" " "
X19	Carbon, coppice dune	Percent
X20	Carbon, dune interspace	"
X21	Carbon, weighted [(X19)(X11/100)+(X20)(X10/100)]	"
X22	Sand fraction in soil surface horizon, coppice dune	"
X23	" " " " " " , dune interspace	"
X24	" " " " " " , weighted [(X22)(X11/100)+(X23)(X10/100)]	"
X25	Silt fraction in soil surface horizon, coppice dune	"
X26	" " " " " " , dune interspace	"
X27	" " " " " " , weighted [(X25)(X100/100)+(X26)(X10/100)]	"
X28	Clay fraction in soil surface horizon, coppice dune	"
X29	" " " " " " , dune interspace	"
X30	" " " " " " , weighted [(X28)(X11/100)+(X29)(X10/100)]	"
X31	Sand fraction in diagnostic subsurface horizon	"
X32	Silt " " " " "	"
X33	Clay " " " " "	"
X34	Depth of surface horizon, coppice dune	Inches
X35	" " " " , dune interspace	"
X36	" " " " , weighted [(X34)(X11/100)+(X35)(X10/100)]	"
X37	Initial soil surface moisture, air dry	Pounds per cubic foot
X38	" " " " , field capacity	" " " "
X39	Runoff, application rate 3 inches per hour, soil surface initially dry	Inches
X40	" " " " " " " , soil surface initially at field capacity	"
X41	" " " " " " " , soil surface initially dry	"
X42	" " " " " " " , soil surface initially at field capacity	"

RESULTS

Results are discussed in two main sections as follows: 1) treatment effects and 2) factors influencing infiltration and sediment production.

Treatment Effects

A one-way analysis of variance and Duncan's New Multiple Range Test were used to determine the difference in infiltration rates and sediment production among plant communities and soils by watershed.

INFILTRATION

Mean infiltration curves for the twenty-eight plant communities are given in Appendix A.

Means of all treatments will be discussed generally, however, on most study sites the 1.5-inch per hour application rate did not exceed the coppice dune infiltration rate. Thus, the discussion will be centered on the higher application rate and more specifically those tests where the soil was initially dry. Using the 3-inch per hour application rate, soil initially dry, the highest infiltration rates were observed in Steptoe Watershed with the lowest rates occurring in Duckwater Watershed. Infiltration rates were lower when the soil was initially at field capacity. Highest infiltration rates occur in the coppice dunes and the lowest rates in the dune interspace areas regardless of plant community or soil.

Duckwater Watershed. - Highest infiltration rates occur in the *Pinus monophylla/Juniperus osteosperma* and *Artemisia nova* communities. Conversely the lowest infiltration rates are in the *Eurotia lanata* community (Table 8).

Infiltration rates in the *E. lanata* community are significantly lower than all other communities except *Artiplex confertifolia* for 3-inch per hour application rate. *P. monophylla/J. osteosperma* and *A. nova* communities infiltration rates are significantly higher than all other communities except *A. nova* and *Artemisia tridentata/Chrysothamnus viscidiflorus*, 3-inch per hour application rate, soil initially dry.

Coils Creek Watershed - *Symphoricarpos longiflorus/Artemisia tridentata/Agropyron spicatum/Wyethia mollis* community exhibits the highest infiltration rate and is significantly higher than all other units except *Artemisia tridentata/Poa secunda/Balsamorhiza sagittata*, application rate 3-inch per hour, soil initially dry (Table 9). Lowest infiltration rates occur in the *Artemisia arbuscula/Poa secunda* (low) community which is sifnificantly lower than all other communities, application rate 3-inch per hour, soil initially dry.

Steptoe Watershed - Of the plant communities and soils studied in this watershed, not one has a consistently higher infiltration rate for the various treatments (Table 10). *Pinus monophylla/Juniperus osteosperma* community, however, consistently shows the lowest infiltration rates and is significantly lower than all other communities except *Agropyron desertorum* (low), application rate 3-inch per hour, soil initially dry. Infiltration rates for those communities plowed and seeded to *Agropyron desertorum* (Agde [low] and Agde) are not significantly different from their undisturbed counterparts (Artr and Artr/Agsp).

Pine and Mathews Canyon Watersheds - *Juniperus osteosperma* community has the highest infiltration rate for the lower application rate, where *Artemisia nova/Agropyron intermedium* and *J. osteosperma/Agropyron desertorum* exhibit higher infiltration rates for the 3-inch per hour application rate. (Table 11). *J. osteosperma/Artemisia tridentata/Sutanion hystrix* community infiltration rate is the lowest for the 1.5-inch per hour application rate, however, *A. tridentata/Chrysothamnus nauseosus* is lower for the 3-inch per hour application rate. *A. tridentata/C. nauseosus* community is significantly lower than *A. nova/A. intermedium, J. osteosperma,* and *A. tridentata/A. desertorum* community infiltration rate is significantly larger than its undisturbed counterpart (Artr/Chna) for application rate 3-inch per hour dry and at field capacity. All other treated communities are not significantly different from their untreated counterparts.

Coppice Dune and Dune Interspace Areas - Coppice dune and dune interspace area mean infiltration curves for selected plant communities are presented in Figures 5 through 10. Infiltration rates for shrub or grass (Artr, Agde, only) coppice dunes are significantly higher than corresponding dune interspace areas. Highest infiltration rates are in *A. tridentata/A. desertorum* and *A. arbuscula/Poa secunda* (low) coppice dunes and lowest rates occur in *A. tridentata* and *A. arbuscula/P. secunda* (low) dune interspace areas. The only grass coppice dune sampled (Artr/Agde) has a significantly higher infiltration rate than its untreated big sagebrush coppice dune counterpart (Artr/Chna) (Table 12).

Table 8. Mean infiltration rates (in/hr) for the nine plant communities at Duckwater Watershed ranked according to magnitude in decreasing order.

Application rate (in/hr)	Initial Soil Moisture Condition	Plant Community								
		Pimo/[1/] Juos	Arno	Artr/ Chvi	Atco/ Eula	Artr	Juos	Arno/ Atco	Atco	Eula
1.5[2/]	Dry	1.41^{a}	1.33^{b}	1.28^{c}	1.23^{d}	1.19^{ae}	1.14^{af}	1.04^{abcg}	1.02^{abch}	$0.78^{abcdefgh}$
		Pimo/ Juos	Arno	Juos	Artr/ Chvi	Atco/ Eula	Atco	Artr	Arno/ Atco	Eula
1.5[2/]	Field Capacity	1.41^{a}	1.06^{ab}	1.01^{ac}	0.85^{ad}	0.81^{ae}	0.73^{abcf}	0.71^{abcg}	0.68^{abch}	$0.40^{abcdefgh}$
		Pimo/ Juos	Arno	Artr/ Chvi	Artr	Arno/ Atco	Atco/ Eula	Juos	Atco	Eula
3.0[3/]	Dry	2.85^{a}	2.70^{b}	2.40^{ac}	2.16^{abd}	2.10^{abe}	1.98^{abf}	1.97^{abcg}	1.75^{abcdef}	$1.38^{abcdefg}$
		Pimo/ Juos	Arno	Juos	Atco/ Eula	Artr/ Chvi	Arno/ Atco	Artr	Atco	Eula
3.0[3/]	Field Capacity	2.79^{a}	2.05^{ab}	1.71^{ac}	1.58^{abd}	1.52^{abe}	1.49^{abf}	1.42^{abg}	1.26^{ab}	$0.87^{abcdefg}$

The mean occurring first with a letter superscript is significantly different from all other means having the same letter superscript (.05 level), read in rows from left to right.

1/ Mean infiltration rate (1.41) for the Pimo/Juos community is significantly larger than the mean infiltration rate of any other mean with the same superscript (Artr, Juos, Atco, Arno/Atco and Eula communities). Likewise, mean infiltration rate (1.19) for the Artr community is significantly larger than the mean infiltration for Eula community.

2/ Mean values for 60 min. test.

3/ Mean values for 30 min. test.

Table 9. Mean infiltration rates (in/hr) for the six plant communities at Coils Creek Watershed ranked according to magnitude in decreasing order.

Application rate (in/hr)	Initial Soil Moisture Condition	Plant Community					
		Sylo/ Artr/ Agsp/ Wymo	Artr/ Agsp/ Basa	Pimo/ Juos/ Arar/ Pose	Artr/ Pose/ Phdi	Arar/ Pose	Arar/ Pose (Low)
1.5[1/]	Dry	1.41^{a}	1.42^{b}	1.39^{c}	1.31^{d}	1.27^{ab}	1.19^{abd}
		Sylo/ Artr/ Agsp/ Wymo	Artr/ Agsp/ Basa	Pimo/ Juos/ Arar/ Pose	Artr/[3/] Pose/ Phdi	Arar/ Pose	Arar/ Pose (Low)
1.5[1/]	Field Capacity	1.33^{a}	1.19^{b}	1.16^{c}	1.03	1.02^{a}	0.87^{abc}
		Sylo/ Artr/ Agsp/ Wymo	Artr/ Agsp/ Basa	Pimo/ Juos/ Arar/ Pose	Arar/ Pose	Artr/ Pose/ Phdi	Arar/ Pose (Low)
3.0[2/]	Dry	2.68^{a}	2.60^{b}	2.42^{ac}	2.40^{ad}	2.39^{ae}	1.97^{abcde}
		Sylo/ Artr/ Agsp/ Wymo	Artr/ Agsp/ Basa	Pimo/ Juos/ Arar/ Pose	Arar/ Pose	Artr/ Pose Phdi	Arar/ Pose (Low)
3.0[2/]	Field Capacity	2.39^{a}	2.36^{b}	1.87^{ab}	1.82^{ab}	1.73^{ab}	1.62^{ab}

The mean occurring firstwith a letter superscript is significantly different from all other means having the same letter superscript (.05 level), read in rows from left to right

1/ Mean values for the 60 min. test.

2/ Mean values for the 30 min. test.

3/ Mean is not significantly different from other means (.05 level).

Table 10. Mean infiltration rates (in/hr) for the six plant communities at Steptoe Watershed ranked according to magnitude in decreasing order.

Application rate (in/hr)	Initial Soil Moisture Condition	Plant Community					
		Agde (Low)	Artr	Artr/ Putr/ Agsp	Agde (High)	Artr/ Agsp	Pimo/ Juos
1.5[1/]	Dry	1.49^{a}	1.46^{b}	1.45^{c}	1.41	1.39	1.33^{abc}
		Artr	Agde (Low)	Artr/ Agsp	Artr/ Putr/ Agsp	Agde (High)	Pimo/ Juos
1.5[1/]	Field Capacity	1.38^{a}	1.25^{b}	1.26^{c}	1.25^{d}	1.19^{e}	1.01^{abcde}
		Artr/ Agsp	Agde (High)	Artr/ Putr/ Agsp	Artr	Agde (Low)	Pimo/ Juos
3.0[2/]	Dry	2.87^{a}	2.82^{b}	2.82^{c}	2.78^{d}	2.69	2.55^{abcd}
		Artr	Agde (High)	Artr/ Agsp	Artr/ Putr/ Agsp	Agde (Low)	Pimo/ Juos
3.0[2/]	Field Capacity	2.69^{a}	2.47^{b}	2.41^{c}	2.35^{d}	2.23^{e}	1.79^{abcde}

The mean occurring first with a letter superscript is significantly different from all other means having the same letter superscript (.05 level), read in rows from left to right.

1/ Mean values for 60 min. test.

2/ Mean values for 30 min. test.

Table 11. Mean infiltration rates (in/hr) for the seven plant communities at Pine and Mathews Canyon Watersheds ranked according to magnitude in decreasing order.

Application rate (in/hr)	Initial Soil Moisture Condition	Plant Community						
		Juos	Arno/Agin	Pimo/Juos/Arno/Ampa	Artr/Chna	Artr/Agde	Juos/Agde	Juos/Artr/Sihy
1.5[1/]	Dry	1.46^{a}	1.44^{b}	1.42^{c}	1.41^{d}	1.36	1.35	1.18^{abcd}
		Juos	Pimo/Juos/Arno/Ampa	Arno/Agin	Juos/Agde	Artr/Agde	Artr/Chna	Juos/Artr/Sihy
1.5[1/]	Field Capacity	1.34^{a}	1.33^{b}	1.25	1.22	1.08	1.06	0.97^{ab}
		Arno/Agin	Juos	Artr/Agde	Juos/Agde	Pimo/Juos/Arno/Ampa	Juos/Artr/Sihy	Artr/Chna
3.0[2/]	Dry	2.84^{a}	2.52	2.50	2.46	2.41	2.21^{a}	2.09^{a}
		Juos/Agde	Arno/Agin	Pimo/Juos/Arno/Ampa	Artr/Agde	Juos	Juos/Artr/Sihy	Artr/Chna
3.0[2/]	Field Capacity	2.38^{a}	2.31^{b}	2.14^{c}	2.05^{d}	1.97	1.95	1.29^{abcd}

The mean occurring first with a letter superscript is significantly different from all other means having the same letter superscript (.05 level), read in rows from left to right.

1/ Mean values for 60 min. test.

2/ Mean values for 30 min. test.

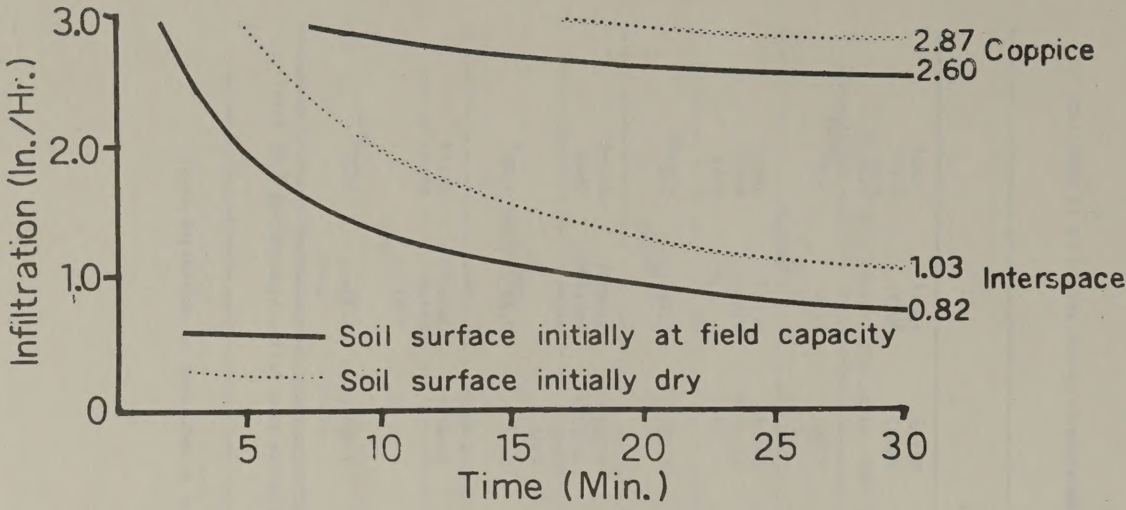


Figure 5. Infiltration curves for the *Artemisia tridentata* community, Duckwater Watershed.

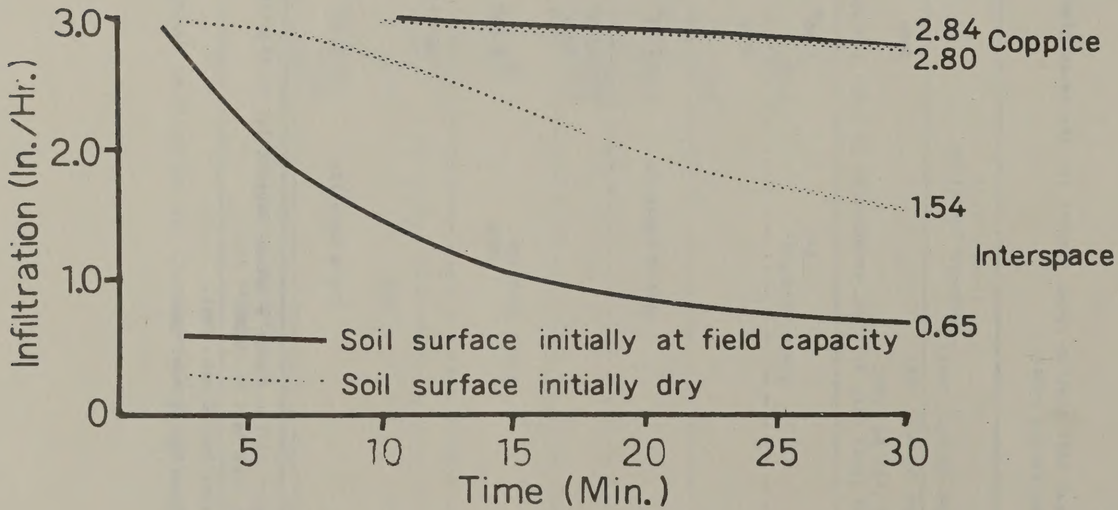


Figure 6. Infiltration curves for the *Artemisia arbuscula/Poa secunda* (low) community, Coils Creek Watershed.

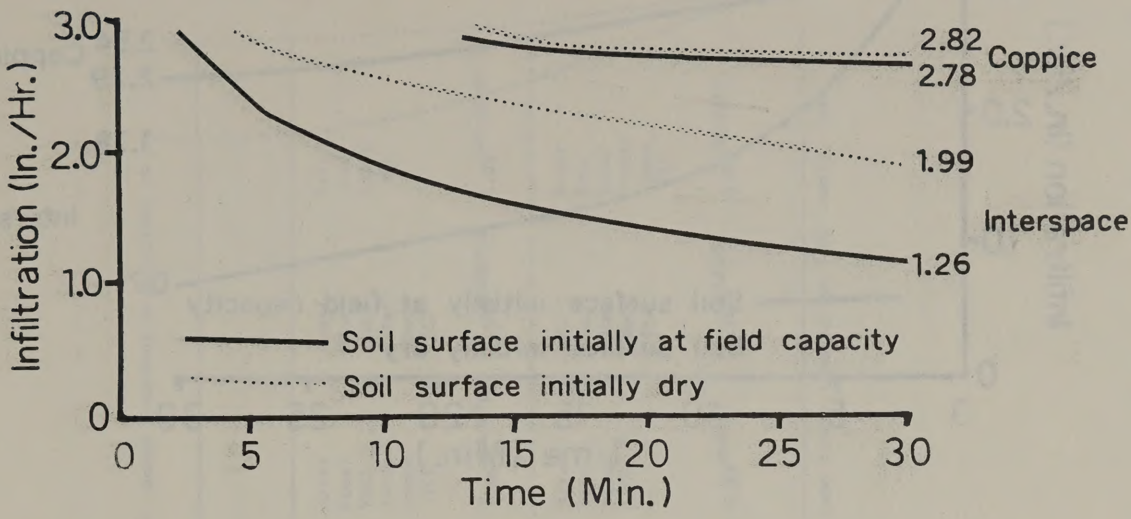


Figure 7. Infiltration Curves for the *Artemisia tridentata/ Balsamorhiza sagittata* community, Coils Creek Watershed.

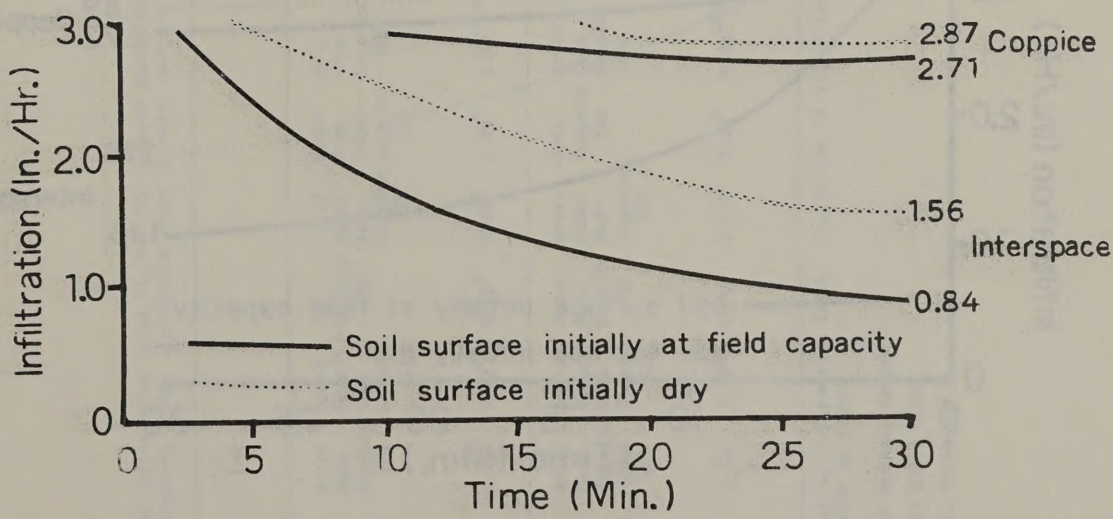


Figure 8. Infiltration curves for the *Artemisia Tridentata/ Poa secunda/Phlox diffusa* community, Coils Creek Watershed.

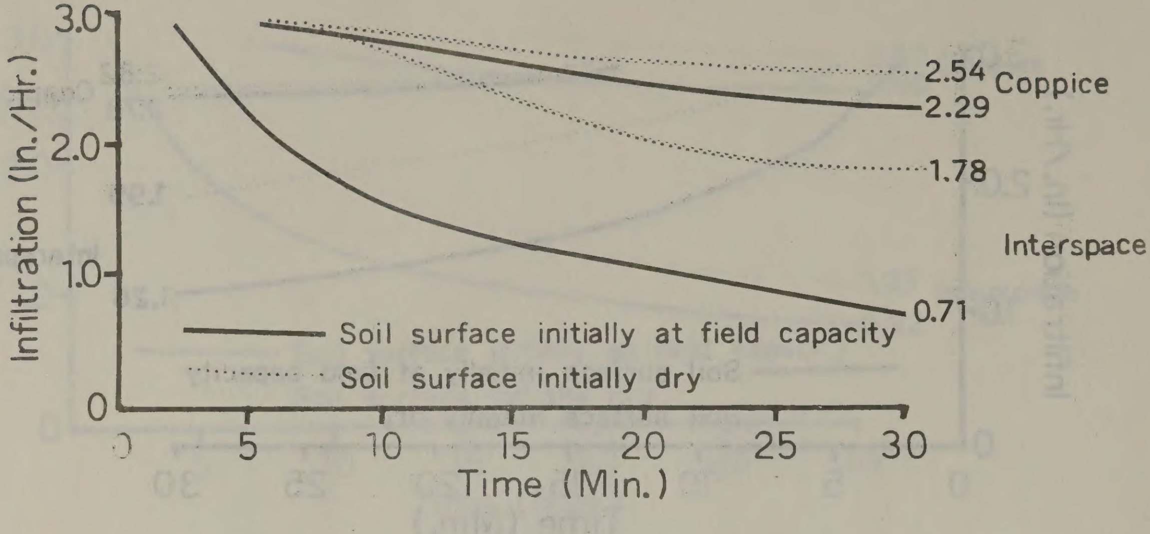


Figure 9. Infiltration curves for the *Artemisia tridentata/ Chrysothamnus nauseous* community, Mathews Canyon Watershed.

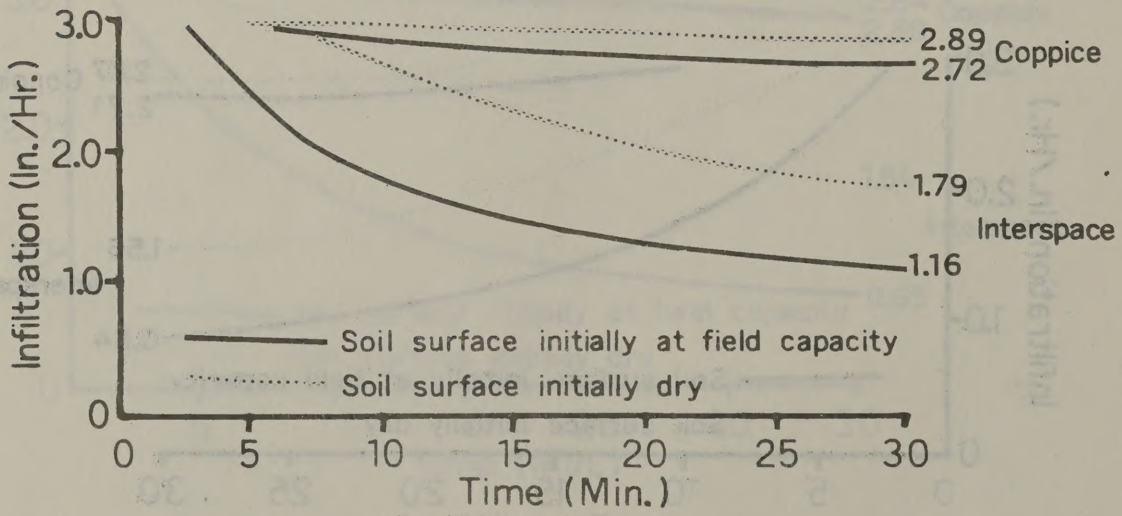


Figure 10. Infiltration curves for the *Artemisia tridentata/ Agropyron desertorum* community, Mathews Canyon Watershed.

Table 12. Mean infiltration rates (in/hr) for coppice dune and dune interspace areas for six plant communities ranked according to magnitude in decreasing order, application rates 3 inches per hour.

Initial Soil Moisture Condition	Plant Community											
	Artr/ Agde Coppice (M)	Artr/ Pose/ Phdi Coppice (C)	Artr Coppice (D)	Artr/ Agsp/ Basa Coppice (C)	Arar/ Pose (Low) Coppice (C)	Artr/ Chna Coppice (M)	Artr/ Agsp/ Basa Inter- space (C)	Artr/ Agde Inter- space (M)	Artr/ Chna Inter- space (M)	Artr/ Pose/ Phdi Inter- space (C)	Arar/ Pose (Low) Inter- space (C)	Artr Inter- space (D)
Dry	2.89^{a}	2.87^{b}	2.87^{c}	2.82^{d}	2.80^{e}	2.54^{abcdef}	$1.99^{abcdefg}$	$1.79^{abcdefh}$	$1.78^{abcdefi}$	$1.56^{abcdefgj}$	$1.54^{abcdefgk}$	$1.03^{abcdefghijk}$

Initial Soil Moisture Condition	Plant Community											
	Arar/ Pose Coppice (Low) (C)	Artr/ Agsp/ Basa Coppice (C)	Artr/ Agde Coppice (M)	Artr/ Pose/ Phdi Coppice (C)	Artr Coppice (D)	Artr/ Chna Coppice (M)	Artr/ Agsp/ Basa Inter- space (C)	Artr/ Agde Inter- space (M)	Artr/ Pose/ Phdi Inter- space (C)	Artr Inter- space (D)	Artr/ Chna Inter- space (M)	Arar/ Pose (Low) Inter- space (C)
Field Capacity	2.84^{a}	2.78^{b}	2.72^{c}	2.71^{d}	2.60^{e}	2.29^{abcdf}	1.26^{abcdg}	1.16^{abcdef}	0.84^{abcdef}	0.82^{abcdef}	$0.71^{abcdefg}$	$0.65^{abcdefg}$

The mean occuring first with a letter superscript is significantly different from all other means having the same letter superscript (.05 level), read in rows from left to right.

Watershed: (M)= Mathews Canyon

(C)= Coils Creek

(D)= Duckwater

Table 13. Mean sediment production (tons/acre) for the nine plant communities at Duckwater Watershed ranked according to magnitude in decreasing order.

Application rate (in/hr)	Initial Soil Moisture Condition	Plant Community								
		Atco	Eula	Arno/ Atco	Artr/ Chvi	Artr	Atco/ Eula	Arno	Juos	Pimo/ Juos
1.5[1/]	Dry	0.409^{a}	0.324^{b}	0.323^{c}	0.298^{d}	0.208^{a}	0.188^{f}	0.183^{g}	$0.029^{abcdefgh}$	$0.004^{abcdefgh}$
		Artr/ Chvi	Eula	Arno/ Atco	Atco	Arno	Artr	Atco/ Eula	Juos	Pimo/ Juos
1.5[1/]	Field Capacity	0.487^{a}	0.339^{b}	0.323^{c}	0.303^{d}	0.288^{e}	0.282^{f}	0.179^{g}	$0.023^{abcdefgh}$	$0.004^{abcdefgh}$
		Artr/ Chvi	Atco	Eula	Arno/ Atco	Artr	Atco/ Eula	Arno	Juos	Pimo/ Juos
3.0[2/]	Dry	0.642^{a}	0.594^{b}	0.552^{c}	0.386^{d}	0.262^{e}	0.235^{f}	0.140^{ag}	0.122^{abch}	$0.003^{abcdefgh}$
		Atco	Artr/ Chvi	Eula	Arno/ Atco	Artr	Arno	Atco/ Eula	Juos	Pimo/ Juos
3.0[2/]	Field Capacity	0.673^{a}	0.666^{b}	0.522^{c}	0.508^{d}	0.359^{e}	0.266^{f}	0.243^{g}	0.071^{abcdeh}	$0.003^{abcdefgh}$

The mean occurring first with a letter superscript is significantly different from all other means having the same letter superscript (.05 level), read in rows from left to right.

1/ Mean values for 60 min. test.

2/ Mean values for 30 min. test.

Table 14. Mean sediment production (tons/acre) for the six plant communities at Coils Creek Watershed ranked according to magnitude in decreasing order.

Application rate (in/hr)	Initial Soil Moisture Condition	Plant Community					
		Arar/ Pose	Arar/ Pose (Low)	Artr/ Pose/ Phdi	Sylo/ Artr/ Agsp/ Wymo	Artr/ Agsp/ Basa	Pimo/ Juos/ Arar/ Pose
1.5[1/]	Dry	0.34[a]	0.26[b]	0.16[c]	0.11[d]	0.06	0.01[abcd]
		Arar/ Pose	Artr/ Pose/ Phdi	Pimo/ Juos/ Arar/ Pose	Arar/ Pose (Low)	Artr/ Agsp/ Basa	Sylo/ Artr/ Agsp/ Wymo
1.5[1/]	Field Capacity	0.47[a]	0.40[b]	0.37[c]	0.36[d]	0.19[a]	0.16[abcd]
		Arar/ Pose	Arar/ Pose (Low)	Pimo/ Juos/ Arar/ Pose	Artr/ Pose/ Phdi	Artr/ Agsp/ Basa	Sylo Artr/ Agsp/ Wymo
3.0[2/]	Dry	0.63[a]	0.48[b]	0.42	0.38[a]	0.25[a]	0.22[ab]
		Arar/ Pose	Artr/ Pose/ Phdi	Pimo/ Juos/ Arar/ Pose	Arar/ Pose (Low)	Artr/ Agsp/ Basa	Sylo/ Artr/ Agsp/ Wymo
3.0[2/]	Field Capacity	1.25[a]	0.87[b]	0.62[ac]	0.58[ad]	0.37[ab]	0.32[abcd]

The mean occurring first with a letter superscript is significantly different from all other means having the same letter superscript (.05 level), read in rows from left to right.

1/ Mean values for the 60 min. test.

2/ Mean values for the 30 min. test.

Table 15. Mean sediment production (tons/acre) for the six plant communities at Steptoe Watershed ranked according to magnitude in decreasing order.

Application rate (in/hr)	Initial Soil Moisture Condition	Plant Community					
1.5[1/]	Dry	Pimo/ Juos 0.25^{a}	Artr/ Agsp 0.07^{b}	Artr Putr/ 0.03	Agde (High) 0.02	Artr 0.008^{a}	Agde (Low) 0.003^{ab}
1.5[1/]	Field Capacity	Pimo/ Juos 0.31^{a}	Artr/ Putr/ Agsp 0.24^{b}	Artr/ Agsp 0.10	Agde (High) 0.07	Artr 0.03^{a}	Agde (Low) 0.02^{ab}
3.0[2/]	Dry	Pimo/ Juos 0.20^{a}	Artr/ Agsp 0.14^{b}	Artr/ Putr/ Agsp 0.08	Agde (High) 0.07	Agde (Low) 0.04	Artr 0.01^{ab}
3.0[2/]	Field Capacity	Pimo/ Juos 0.52^{a}	Artr/ Putr/ Agsp 0.36^{b}	Agde (High) 0.21	Artr/ Agsp 0.13	Agde (Low) 0.09^{a}	Artr 0.07^{ab}

The mean occuring first with a letter superscript is significantly different from all other means having the same letter superscript (.05 level), read in rows from left to right.

1/ Mean values for 60 min. test.

2/ Mean values for 30 min. test.

SEDIMENT PRODUCTION

All treatments will be discussed generally, however, the discussion will be centered around 3-inch per hour application rate, soil initially dry. Soils at Duckwater Watershed generally produced the largest quantities of sediment and the lower sediment production occurring at Steptoe and Pine and Mathews Canyon Watersheds. Largest sediment production usually comes from soils initially at field capacity. Majority of sediment comes from dune interspace areas rather than from coppice dunes.

Duckwater Watershed - Largest quantities of sediment come from the *A. tridentata/C. viscidiflorus*, *A. confertifolia*, , and *E. lanata* communities and the smallest quantities from *J. osteosperma* and *P. monophylla/J. osteosperma* communities (Table 13). Sediment produced from *P. monophylla/J. osteosperma* community is significantly smaller than other communities sampled for all treatments.

Coils Creek Watershed - Largest quantities of sediment are produced from the *A. arbuscula/P. secunda* and *A. arbuscula/P. secunda* (low) communities. Smallest quantities of sediment came from *A. tridentata/P. secunda/B. sagitiata* and *S. longiflorus/A. tridentata/A. spicatum/W. mollis* communities where the latter communities sediment production is significantly smaller than *A. arbuscula/P. secunda* *A. arbuscula* and *P. secunda* (low), application rate 3-inch per hour, soil initially dry (Table 14).

Steptoe Watershed - *P. monophylla/J. osteosperma* community consistently produced more sediment than other sampled communities. Lowest sediment comes from *A. tridentata* and *A. desertorum* (low) communities (Table 15). Sediment from these two communities is significantly lower than that produced from *P. monophylla/J. osteosperma* community for most treatments. Communities that have been plowed and seeded to *A. desertorum* (Agde (low), Agde) shows no significant difference nor trend in sediment production from their unseeded counterparts (Artr, Artr/Agsp).

Pine and Mathews Canyon Watersheds - *A. tridentata/C. nauseous* *P. monophylla/J. osteosperma/A. nova/A. ainifolia* communities produced the largest quantities of sediment, application rate 3-inch per hour (Table 16). Lowest sediment production communities are *J. osteosperma/A. desertorum*, *A. nova/A. intermedium*, and *J. Osteosperma/A. tridentata/S. hystrix*. Communities that have been railed and seeded or chained and seeded (Artr/Agde, Arno/Agin, and Juos/Agde) show no significant difference in sediment production from their unseeded counterparts (Artr/Chna, Pimo/Juos/Arno/Ampa, and Juos/Artr/Sihy). However, there is a trend of larger sediment quantities produced from untreated sites.

Coppice Dune and Dune Interspace Areas - Sediment production is usually considerably higher from dune interspace areas than coppice dunes except for *A. tridentata/C. nauseous* community. Sediment produced from dune interspace areas of the three communities sampled at Coils Creek Watershed are significantly higher than that produced from corresponding coppice dunes (Table 17). Difference in sediment production from coppice dunes and dune interspace areas ranged from no differences to as much as 46 times more sediment produced from *A. tridentata/P. secunda/P. diffusa* community dune interspace areas than from its corresponding coppice dunes.

Table 16. Mean sediment production (tons/acre) for the seven plant communities at Pine and Mathews Canyon Watersheds ranked according to magnitude in decreasing order.

Application rate (in/hr)	Initial Soil Moisture Condition	Plant Community						
		Artr/ Chna	Pimo/ Juos/ Arno/ Ampa	Artr/ Agde	Juos/ Artr/ Sihy	Juos	Arno/ Agin	Juos/ Agde
1.5 1/	Dry	0.12	0.05	0.04	0.03	0.02	0.02	0.007
		Artr/ Agde	Artr/ Chna	Pimo/ Juos/ Arno/ Ampa	Juos/ Artr/ Sihy	Juos	Arno/ Agin	Juos/ Agde
1.5 1/	Field Capacity	0.34^{a}	0.22^{b}	0.05	0.03	0.02^{a}	0.02^{ab}	0.01^{ab}
		Artr/ Chna	Pimo/ Juos/ Arno/ Ampa	Artr/ Agde	Juos/ Agde	Juos	Arno/ Agin	Juos/ Artr/ Sihy
3.0 2/	Dry	0.40	0.38	0.22	0.06	0.05	0.04	0.04
		Pimo/ Juos/ Arno/ Ampa	Artr/ Chna	Artr/ Agde	Arno/ Agin	Juos	Juos/ Artr/ Sihy	Juos/ Agde
3.0 2/	Field Capacity	0.54^{a}	0.45^{b}	0.35^{c}	0.23^{d}	0.16^{e}	0.03^{abcd}	0.02^{abcde}

The mean occurring first with a letter superscript is significantly different from all other means having the same letter superscript (.05 level), read in rows from left to right.

1/ Mean values for 60 min. test.

2/ Mean values for 30 min. test.

Table 17. Mean sediment production (tons/acre) for coppice dune and dune interspace areas for six plant communities ranked according to magnitude in decreasing order, application rate 3 inches per hour.

Initial Soil Moisture Condition	Plant Community											
	Artr/ Agde Inter-space (M)	Artr/ Pose/ Phdi Inter-space (C)	Artr/ Chna Coppice (M)	Artr/ Agsp/ Basa Inter-space (C)	Artr/ Chna Inter-space (M)	Arar/ Pose Inter-space	Artr/ Agde Coppice (M)	Artr Inter-space (D)	Artr Coppice (D)	Arar/ Pose Coppice (C)	Artr/ Agsp/ Basa Coppice (C)	Artr/ Pose/ Phdi Coppice (C)
Dry	0.26^{a}	0.23^{b}	0.18^{c}	0.17^{d}	0.16^{e}	0.15^{f}	0.15^{g}	0.10^{h}	0.05	$0.02^{abcdefg}$	$0.01^{abcdefghi}$	$0.005^{abcdefghi}$
	Artr/ Agsp/ Basa Inter-space (C)	Arar/ Pose (Low) Inter-space (C)	Artr/ Pose/ Phdi Inter-space (C)	Artr/ Agde Inter-space (M)	Artr/ Chna Coppice (M)	Artr Inter-space (D)	Artr/ Chna Inter-space (M)	Artr Coppice (D)	Artr/ Agde Coppice (M)	Artr/ Agsp/ Basa Coppice (C)	Artr/ Pose/ Phdi (C)	Arar/ Pose (Low) (C)
Field Capacity	0.32^{a}	0.32^{b}	0.31^{c}	0.24^{d}	0.16	0.16	0.15	0.11	0.06	0.03^{abcd}	0.03^{abcd}	0.03^{abcd}

The mean occuring first with a letter superscript is significantly different from all other means having the same letter superscript (.05 level), read in rows from left to right.

Watershed: (M) = Mathews Canyon
(C) = Coils Creek
(D) = Duckwater

Table 18. Independent variables appearing in regression equations.

Number	Description	Terms Used In Description
	Infiltration	
X7	Rock (1/8 to 2 inches in any dimension)	Percent
X9	Bare ground	"
$(X9)^2$	Bare ground, squared	"
X10	Dune interspace	"
X11	Coppice dune	"
$(X11)^2$	Coppice dune, squared	"
X12	Litter	"
X13	Plant cover	"
X15	Roughness factor	Inches squared
X16	Soil surface horizon morphological rating, coppice dune	1 to 5
X17	" " " " " , dune interspace	" " "
X18	" " " " " , weighted [(X16)(X11/100)+(X17)(X10/100)]	" " "
X20	Carbon, dune interspace	Percent
X25	Silt fraction in soil surface horizon, coppice dune	"
X26	" " " " " " , dune interspace	"
X27	" " " " " " , weighted [(X25)(X11/100)+(X26)(X10/100)]	"
X30	Clay fraction in soil surface horizon, weighted [(X28)(X11/100)+(X29)(X10/100)]	"
X35	Depth of surface horizon, interspace	Inches
X36	" " " " , weighted [(X34)(X11/100)+(X35)(X10/100)]	"
	Sediment	
X4	Soil bulk density in surface 0 to 4 inches, dune interspace	Grams per cubic centimer
X7	Rock (1/8 to 2 inches in largest dimension)	Percent
X8	Rock (> 2 inches in largest dimension)	"
X9	Bare ground	"
X10	Dune interspace	"
$(X10)^2$	Dune interspace, squared	"
$(X10)^{0.5}$	Dune interspace, square root	"
X11	Coppice dune	"
X12	Litter	"
X15	Roughess factor	Inches squared
X20	Carbon, dune interspace	Percent
X21	Carbon, weighted	"
$[(X10)(X21)]^2$	Dune interspace times weighted carbon, squared	"
X7+X11+X12+X21	Rock (1/2 to 2 inches in largest dimension) plus coppice dune plus litter plus carbon, weighted	"
X24	Sand fraction in soil surface horizon, weighted	"
$[(X21)(X24)]^2$	Carbon, weighed times sand fraction in soil surface horizon, weighted; squared	"
X37	Initial soil surface moisture, air dry	Pounds per cubic foot
X38	Initial soil surface moisture, field capacity	" " " "

Table 19. Mean and standard deviation of the variables appearing in regression equations by watershed, infiltration.

	Variable	Application Rate 3 Inches Per Hour		Application Rate 1 1/2 Inches Per Hour	
		Mean	Standard Deviation	Mean	Standard Deviation
	Duckwater Watershed				
X 9	Bare ground	32.816	19.449	34.033	18.939
X10	Dune interspace	62.630	33.020	66.366	29.221
X13	Plant cover	23.253	22.063	19.464	17.535
X18	Soil surface horizon morphological rating, weighted	3.045	1.250	2.869	1.168
X27	Silt fraction in soil surface horizon, weighted	23.952	9.009	24.322	9.458
X36	Depth of surface horizon, weighted	4.212	1.496	4.292	1.492
	Coils Creek Watershed				
X 9	Bare ground	18.698	15.772	17.739	11.831
$(X\ 9)^2$	Bare ground, squared	- - -	- - -	462.842	588.303
X10	Dune interspace	54.831	38.692	- - -	- - -
X16	Soil surface horizon morphological rating, coppice dune	- - -	- - -	1.667	0.756
X18	Soil surface horizon morphological rating, weighted	2.354	1.404	- - -	- - -
X27	Silt fraction in soil surface horizon, weighted	27.143	8.119	- - -	- - -
	Steptoe Watershed				
X 7	Rock (1/8 to 2 inches)	- - -	- - -	8.717	14.748
X 9	Bare ground	22.411	13.671	25.017	13.548
X10	Dune interspace	65.928	26.168	- - -	- - -
X11	Coppice dune	34.078	26.163	- - -	- - -
$(X11)^2$	Coppice dune, squared	1826.790	2514.190	- - -	- - -
X13	Plant cover	- - -	- - -	54.018	30.623
X15	Roughness factor	- - -	- - -	0.668	0.370
X16	Soil surface horizon morphological rating, coppice dune	1.003	0.0167	- - -	- - -
X17	Soil surface horizon morphological rating, dune interspace	- - -	- - -	1.500	0.774
X18	Soil surface horizon morphological rating, weighted	1.378	0.651	- - -	- - -
X35	Depth of surface horizon, weighted	4.583	1.032	- - -	- - -
	Pine and Mathews Canyon Watersheds				
X 7	Rock (1/8 to 2 inches)	10.304	11.627	- - -	- - -
X 9	Bare ground	37.011	27.204	34.320	25.596
$(X\ 9)^2$	Bare ground, squared	- - -	- - -	1818.170	2101.820
X10	Dune interspace	60.570	38.112	70.968	33.851
X12	Litter	43.691	35.123	- - -	- - -
X13	Plant cover	31.782	24.963	32.646	25.425
X15	Roughness factor	0.425	0.270	- - -	- - -
X25	Silt fraction in soil surface horizon, coppice dune	33.950	4.614	33.950	4.614

Table 20. Infiltration multiple regression equations by watershed and treatment.

Equation Number	Initial Soil Moisture	Application rate (in/hr)	Regression Equations	Coefficient of Determination R^2	Standard Error of Estimate S. E. E.
			Duckwater Watershed		
1	Dry	3	$Y3=2.808-0.00470(X9)+0.00738(X13)-0.128(X18)-0.0337(X27)+0.123(X36)$	0.723	0.337
2	Field Capacity	3	$Y7=2.865-0.00994(X9)-0.00213(X10)+0.00258(X13)-0.147(X18)-0.0341(X27)+0.118(X36)$	0.748	0.380
3	Dry	1.5	$Y12=1.679-0.00309(X9)+0.00278(X13)-0.0584(X18)-0.0120(X27)$	0.563	0.182
4	Field Capacity	1.5	$Y17=1.653-0.00674(X9)-0.00157(X10)-0.0773(X18)-0.0156(X27)+0.0383(X36)$	0.788	0.176
			Coils Creek Watershed		
5	Dry	3	$Y3=3.243-0.00121(X9)-0.00835(X10)-0.144(X18)-0.00304(X27)$	0.719	0.283
6	Field Capacity	3	$Y7=3.386-0.00230(X9)-0.0144(X10)-0.170(X18)-0.00913(X27)$	0.812	0.345
7	Dry	1.5	$Y12=1.538-0.00347(X9)-0.0886(X16)$	0.479	0.102
8	Field Capacity	1.5	$Y17=1.460-0.00943(X9)-0.114(X16)$	0.559	0.155
			Steptoe Watershed		
9	Dry	3	$Y3=10.119-0.00286(X10)-7.006(X16)-0.106(X18)$	0.436	0.166
10	Field Capacity	3	$Y7=1.405-0.00458(X9)+0.0263(X11)-0.000196(X11)^2-0.163(X18)+0.155(X35)$	0.612	0.279
11	Dry	1.5	$Y12=1.494-0.00226(X7)-0.000279(X9)-0.0290(X17)$	0.323	0.0790
12	Field Capacity	1.5	$Y17=1.297-0.00540(X7)-0.00492(X9)+0.00104(X13)+0.0684(X15)$	0.405	0.158
			Pine and Mathews Canyon Watersheds		
13	Dry	3	$Y3=3.987-0.00404(X9)-0.00169(X10)+0.00392(X12)+0.219(X15)-0.0457(X25)$	0.661	0.281
14	Field Capacity	3	$Y7=2.863-0.0255(X7)-0.00582(X9)-0.00822(X10)+0.00390(X13)$	0.799	0.332
15	Dry	1.5	$Y12=1.468-0.0000562(X9)^2-0.000435(X10)+0.00133(X13)$	0.603	0.116
16	Field Capacity	1.5	$Y17=1.723-0.00535(X9)-0.0000404(X9)^2+0.00102(X13)-0.00942(X25)$	0.606	0.190

Table 21. Factors influencing infiltration rates ranked 1/ in order of importance 2/, 3-inch per hour simulated rainstorm, soil initially dry.

Duckwater Watershed	Coils Creek Watershed	Steptoe Watershed	Pine and Mathews Canyon Watersheds	All Five Watersheds Combined
Silt fraction of soil surface horizon, weighted	Dune inter-space area	Coppice dune surface mor-phological rating	Silt fraction of coppice dunes	Soil surface mor-phological rating, weighted
Depth of sur-face horizon	Soil surface morphological rating weighted	Dune inter-space area	Litter	Organic carbon dune interspace
Plant cover	Silt fraction of soil sur-face horizon, weighted	Soil surface morphological rating, weighted	Bare ground	Dune interspace area
Soil surface morphological rating, weighted	Bare ground		Dune interspace area	Clay fraction of soil surface hor-izon, weighted
Bare ground				

1/ Read in columns, most important factor listed first.

2/ Based on standard partial regression coefficients.

Factors Influencing Infiltration and Sediment Production

Correlation and regression analyses were used to analyze how the independent variables affect infiltration rates and sediment production. A list of all independent and dependent variables is given in Table 7. Those variables appearing in regression equations are given in Table 18.

INFILTRATION

Regression equations by time interval, watershed and treatment are given in Appendix B. These equations will not be discussed in the text and are presented for interest only. Mean and standard deviation of the variables appearing in regression equations are given in Table 19. The following discussion is based on regression equations in Tables 20 and 21. Dependent variables developed in the equations are average infiltration rate by treatment at the end of 30 or 60 minutes.

Equations developed from data where the soil was initially dry had lower standard errors of estimate and R^2 values than those initially at field capacity. Likewise, equations developed from 3-inch per hour application rate data have larger R^2 values and lower standard errors of estimate than 1.5-inch per hour application data.

Duckwater Watershed - Regression equations for this watershed are numbers 1, 2, 3, and 4 in Table 20. Bare ground, dune interspace, plant cover, weighted soil surface horizon morphological rating, weighted percent silt and depth of soil surface horizon explain 72 percent of the variation in Y3 with a standard error of estimate of 0.337 (Equation 1, Table 20).

Weighted percent silt is the most important variable in determining infiltration. Plant cover and dune interspace areas are least important with the other variables being intermediate in their importance (Table 21).

Coils Creek Watershed - Equations 5, 6, 7, and 8 (Table 20) are developed for this watershed. There are basically two types of equations, one for the 3-inch per hour application rate and one for the 1.5-inch per hour rate. For equations 5 and 6, bare ground, dune interspace, weighted soil surface horizon morphological rating, and weighted percent silt of the surface horizon are the important variables. Dune interspace, however, is the most important variable. Weighted soil surface horizon morphological rating and percent silt of the surface horizon are intermediate in importance, and bare ground is the least important variable. These variables explain 72 percent of the variation in Y3 with a standard error of 0.283.

Coppice dune surface horizon morphological rating (X16) and bare ground (X9) are the variables in equations 7 and 8. Coppice dune surface horizon morphological rating is the most important variable in the dry tests with bare ground becoming slightly more important in explaining infiltration in the wet tests.

Steptoe Watershed - Equations 9, 10, 11, and 12 are developed for this watershed. Variables that are most important in explaining infiltration change with different treatments. In these equations rock, bare ground, dune interspace, coppice dune, plant cover, roughness factor, soil surface horizon morphological rating, and weighted depth of soil surface horizon are the important variables. In equation 9 coppice dune surface horizon morphological rating is the most important and weighted soil surface horizon morphological rating the least important variable influencing infiltration. Coppice dune is the most important variable in equation 10. Weighted crust rating and depth of surface horizon are secondary in determining infiltration. The X variables in this equation explained 61 percent of the variation in Y7 with a standard error of estimate of 0.279.

Pine and Mathews Canyon Watersheds - Regression equations for these watersheds are numbers 13, 14, 15, and 16 where pavement, bare ground, dune interspace, litter, plant cover, roughness factor, silt of the surface horizon and coppice dune importance differ with the various treatments. In equation 13, silt of the surface horizon, coppice dune, and litter are the most important variables explaining infiltration and roughness factor the least important. Variables in this equation explain 66 percent of the variation in Y3 with a standard error of estimate of 0.281. In equation 14, dune interspace and pavement become most important in determining infiltration. However, in equations 15 and 16 bare ground is the most important variable determining infiltration.

Combined Analysis - Data from the five watersheds were combined in order to develop some uniform equations that might be more generally applied. Data from the watersheds were analyzed in the following manner:

Duckwater and Coils Creek, Duckwater, Coils Creek and Steptoe, Pine and Mathews Canyons.

Table 22. Infiltration multiple regression equations by treatment, watersheds combined.

Equation Number	Initial Soil Moisture	Application rate (in/hr)	Regression Equations	Coefficient of Determination R^2	Standard Error of Estimate S. E. E.
			Duckwater and Coils Creek Watersheds		
17	Dry	3	$Y3=3.186-0.00358(X10)+0.00314(X13)-0.188(X18)-0.0185(X27)+0.0233(X36)$	0.654	0.350
18	Field Capacity	3	$Y7=3.196-0.00987(X10)+0.00282(X13)-0.193(X18)-0.0120(X26)+0.0302(X36)$	0.741	0.391
19	Dry	1.5	$Y12=1.661-0.00325(X9)+0.00169(X13)-0.0645(X18)-0.00944(X27)$	0.554	0.166
20	Field Capacity	1.5	$Y17=1.803-0.00693(X9)-0.00183(X10)-0.124(X18)-0.00813(X27)$	0.752	0.175
			Duckwater, Coils Creek and Steptoe Watersheds		
21	Dry	3	$Y3=3.329-0.00263(X10)+0.00419(X13)-0.222(X18)-0.00749(X27)+0.0136(X36)$	0.657	0.340
22	Field Capacity	3	$Y7=3.093-0.00338(X9)-0.00790(X10)+0.00213(X13)-0.238(X18)-0.0109(X26)+0.0326(X36)$	0.704	0.407
23	Dry	1.5	$Y12=1.632-0.00296(X9)-0.0832(X18)+0.106(X20)-0.0074(X27)$	0.546	0.160
24	Field Capacity	1.5	$Y17=1.647-0.00672(X9)-0.00112(X10)-0.158(X18)$	0.702	0.185
			Duckwater, Coils Creek, Steptoe, Pine and Mathews Canyon Watersheds		
25	Dry	3	$Y3=3.121-0.00593(X10)-0.163(X18)+0.175(X20)-0.00931(X30)$	0.505	0.393
26	Field Capacity	3	$Y7=3.074-0.0119(X10)-0.176(X18)+0.184(X20)-0.00958(X30)$	0.630	0.447
27	Dry	1.5	$Y12=1.528-0.00332(X9)+0.000988(X13)-0.0759(X18)$	0.399	0.178
28	Field Capacity	1.5	$Y17=1.598-0.00761(X9)-0.000998(X10)-0.0934(X17)$	0.524	0.232

Equations for data combined from Duckwater and Coils Creek Watersheds are numbers 17, 18, 19, and 20 (Table 22) where bare ground (X9), dune interspace (X10), plant cover (X13), weighted soil surface horizon morphological rating (X18), dune interspace (X26), weighted silt (X27), and depth of soil surface horizon (X36) are the important variables. In all 4 equations, weighted soil surface horizon morphological rating is the most important variable in determining infiltration. Depth of the surface horizon is the least important variable in equations 17 and 18, but plant cover and dune interspace are the least important variables in equations 19 and 20. Variables in equation 17 account for 65 percent of the variation in Y3 with a standard error of estimate of 0.350.

Combined analysis of data from Duckwater, Coils Creek and Steptoe Watersheds are shown in equations 21, 22, 23 and 24. Variables important in explaining infiltration change somewhat with different treatments. In these equations, bare ground (X9), dune interspace (X10), plant cover (X13), weighted soil surface horizon morphological rating (X18), dune interspace organtic carbon (X20), dune interspace silt (X26), weighted silt (X27) and depth of surface horizon (X36) are important. Weighted soil surface horizon morphological rating is the most important variable influencing infiltration. The variables in equation 21 account for 66 percent of the variation in Y3 with a standard error of estimate of 0.340.

Equations 25, 26, 27 and 28 are for the combined analysis of Duckwater, Coils Creek, Steptoe, Pine and Mathews Canyon Watersheds. The variables occurring in these equations are: bare ground (X9), dune interspace (X10), soil surface horizon morphological rating (X17), weighted soil surface horizon morphological rating (X18), dune interspace organic carbon (X20), and weighted clay fraction of the surface horizon (X30). Of these variables, weighted soil surface horizon morphological rating is the most important in explaining infiltration. Clay fraction of the surface soil is least important in equations 27 and 28. The four variables in equation 25 explain 50 percent of the variation in Y3 with a standard error of estimate of 0.393.

SEDIMENT PRODUCTION

Mean and standard deviation of variables appearing in regression equations are given in Table 23. The following discussion is based on multiple regression equations in Table 24. Dependent variables developed in the equations are common logarithms of sediment production at the end of 30 or 60 minutes. Equations developed from data where the soil was initially at field capacity usually had the lowest standard error of estimate and highest R^2 values. The better results were obtained from Duckwater and Coils Creek Watersheds with fairly poor equations from Steptoe, Pine and Mathews Canyon Watersheds.

Runoff, as the only independent variable, is highly correlated with sediment production. However, when runoff was included in multiple regression equations, it failed to improve the standard error of estimates or R^2 values. Reason for this relationship is, the same factors influencing infiltration are often the same factors influencing sediment production. Thus, runoff does not appear in reqression equations.

Duckwater Watershed - The regression equations for this watershed are numbers 29, 30, 31, and 32 in Table 24 where rock (X7), dune interspace (X10), coppice dune (X11), litter (X12), weighted carbor (X21), weighted sand fraction for soil surface horizon (X24), initially soil surface moisture dry (X37) and at field capacity (X38) are the important variables. Dune interspace is the most important variable explaining sediment production and initial moisture content the least important. Variables in equation 29 explain 45 percent of the variation in sediment production with a standard error of estimate of 1.018.

Table 23. Mean and standard deviation of the variables appearing in regression equations by watershed, sediment.

	Variable	Application Rate 3 Inches Per Hour: Mean	Application Rate 3 Inches Per Hour: Standard Deviation	Application Rate 1 1/2 Inches Per Hour: Mean	Application Rate 1 1/2 Inches Per Hour: Standard Deviation
		Duckwater Watershed			
$(X10)^2$	Dune interspace	415095.00	339006.00	427585.00	296423.00
(X7+X11+X12+X21)	Rock, coppice dune, litter, carbon weighted	103.49	50.25	97.49	45.20
$(X21 \cdot X24)^2$	Carbon weighted, sand weighted	2178.15	4352.76	3450.68	4941.90
X24	Sand, weighted	56.54	15.81	56.85	16.68
X37	Soil moisture, dry	5.89	0.99	5.89	0.99
X38	Soil moisture, field capacity	11.76	1.42	11.76	1.42
		Coils Creek Watershed			
X4	Bulk density	1.35	0.15	1.33	0.19
X10	Dune interspace	- - -	- - -	59.81	14.44
$(X10)^{0.5}$	Dune interspace	47.10	14.00	7.68	0.96
$(X10 \cdot X21)^2$	Dune interspace, carbon weighted	9201.28	8547.78	8964.54	6044.73
(X7+X11+X12+X21)	Rock, coppice dune, litter, carbon weighted	- - -	- - -	124.23	19.89
X24	Sand, weighted	6.28	3.94	47.12	12.57
		Steptoe Watershed			
X7	Rock	12.59	16.87	- - -	- - -
X12	Litter	53.99	24.25	- - -	- - -
X15	Roughness factor	0.58	0.2[illegible]	0.67	1.37
X20	Carbon, dune interspace	0.75	0.67	1.75	0.67
X26	Silt, dune interspace	- - -	- - -	31.93	11.28
		Pine and Mathews Canyon Watersheds			
X4	Bulk density	1.57	0.39	1.70	0.49
X8	Rock	3.03	3.00	2.77	2.35
X9	Bare ground	1.96	0.94	4.16	8.62
X12	Litter	43.28	38.35	- - -	- - -
X15	Roughness factor	0.44	0.33	0.48	0.31
X20	Carbon, dune interspace	1.12	3.82	0.73	0.18

Table 24. Sediment multiple regression equations by watershed and treatment.

Equation Number	Initial Soil Moisture	Application rate (in/hr)	Regression Equations	Coefficient of Determination R^2	Standard Error of Estimate S. E. E.
			Duckwater Watershed		
29	Dry	3	$Y4=2.268-0.0000534(X21\cdot X24)^2-0.00000198(X10)^3-0.0343(X24)-0.00985(X7+X11+X12+X21)+0.122(X37)$	0.453	1.018
30	Field Capacity	3	$Y8=0.586-0.000180(X21\cdot X24)^2-0.000002363(X10)^3-0.0149(X24)-0.00575(X7+X11+X12+X21)+0.118(X38)$	0.553	0.972
31	Dry	1.5	$Y13=3.425-0.0000478(X21\cdot X24)^2-0.00000471(X10)^3-0.0346(X24)-0.0142(X7+X11+X12+X21)+0.149(X37)$	0.708	0.880
32	Field Capacity	1.5	$Y18=1.216-0.000188(X21\cdot X24)^2-0.00000486(X10)^3-0.00557(X24)-0.0124(X7+X11+X12+X21)+0.157(X38)$	0.647	1.026
			Coils Creek Watershed		
33	Dry	3	$Y4=0.0728-2.031(X4)-0.0000520(X10\cdot X21)^2-0.00103(X24)+0.319(X10)^{0.5}$	0.451	1.094
34	Field Capacity	3	$Y8=0.895-1.784(X4)-0.0000758(X10\cdot X21)^2-0.0155(X24)+0.332(X10)^{0.5}$	0.424	1.045
35	Dry	1.5	$Y13=-28.520-2.602(X4)+0.705(X10)-0.0177(X24)-0.0274(X7+X11+X12+X21)+10.058(X10)^{0.5}$	0.538	0.538
36	Field Capacity	1.5	$Y18=3.629-0.360(X4)+0.000900(X10)-0.0000160(X10\cdot X21)^2-0.00423(X24)-0.0175(X7+X11+X12+X21)+0.156(X10)^{0.5}$	0.464	0.266
			Steptoe Watershed		
37	Dry	3	$Y4=0.729-0.0179(X7)-0.0342(X12)-0.0644(X20)$	0.386	0.819
38	Field Capacity	3	$Y8=0.475-0.0138(X7)-0.0342(X12)+0.763(X15)-0.0640(X20)$	0.314	0.718
39	Dry	1.5	$Y13=0.726+0.894(X15)-1.362(X20)+0.0000410(X26)$	0.218	1.812
40	Field Capacity	1.5	$Y18=1.518+0.867(X15)-0.576(X20)+0.0388(X26)$	0.275	1.26
			Pine and Mathews Canyons Watersheds		
41	Dry	3	$Y4=2.184+0.678(X4)+0.00845(X8)-0.0249(X12)+1.411(X15)$	0.239	1.564
42	Field Capacity	3	$Y8=0.0757+0.102(X4)+0.0754(X9)+0.224(X8)+0.0367(X15)-0.0277(X20)$	0.532	0.0399
43	Dry	1.5	$Y13=-1.454+0.203(X4)+0.0563(X8)+0.350(X9)+0.187(X15)-1.646(X20)$	0.314	1.732
44	Field Capacity	1.5	$Y18=-0.761+0.963(X4)+0.177(X9)+0.0440(X8)+0.392(X15)-0.00566(X20)$	0.205	1.587

Coils Creek Watershed - Regression equations for this watershed are numbers 33, 34, 35, and 36 where soil bulk density 0 to 4 inches (X4), rock (X7), dune interspace (X10), coppice dune (X11), litter (X12), weighted carbon (X21), weighted sand fraction in soil surface horizon (X24) are the important variables. Dune interspace is the most important variable in determining sediment production and weighted sand fraction the least important. Variables in equation 33 explain 45 percent of the variation in sediment production with a standard error of estimate of 1.094.

Steptoe Watershed - Regression equations for this watershed are numbers 37, 38, 39 and 40 where pavement (X7), litter (X12), roughness factor (X15), dune interspace carbon (X20), and silt fraction in the surface horizon dune interspace (X26) are the important variables. Important variables differ somewhat with treatment. For equations 37 and 38, litter is the most important variable explaining sediment production and dune interspace carbon the least important. Variables in equation 38 account for 31 percent of the variation in sediment production with a standard error of estimate of 0.718.

Pine and Mathews Canyon Watersheds - Regression equations for these watersheds are 41, 42, 43 and 44 where soil bulk density 0 to 4 inches (X4), rock (X8), bare ground (X9), litter (X12), roughness factor (X15), and dune interspace carbon (X20) are the important variables. Importance of variables in explaining sediment production varies from equation to equation with the same variable not being the most important or least important in more than one equation. Standard error of estimate is quite high and R^2 values low for all four equations.

Combined analysis - Because of the high standard error of estimates and low R^2 values for the combined data analyses, the equations are not presented.

DISCUSSION

Factors Influencing Infiltration

Many plant communities occurring in the Great Basin are characterized by a shrub overstory and very sparse vegetation between shrubs (Figure 11). These low seral plant communities usually have an accumulation of soil and organic matter under shrubs called a coppice dune and the area between coppice dunes is referred to as dune interspace (Figure 12).

According to Duley and Kelly (1939), infiltration rates of a site should be the same or very similar for different rainfall intensities as long as the terminal infiltration rate is exceeded. To demonstrate this simulated rainfall was applied to dune interspace areas of the winterfat community at a rate of 3, 1½, .97, 0.57, 0.44 and 0.22 inches per hour. It wasn't until rainfall intensities of 0.57, 0.44 and 0.22 for air-dry soil and 0.22 for soil initially at field capacity that infiltration rates dropped below a fairly constant terminal rate (Table 25). This was not the case, however, when coppice dunes and dune interspace areas were included in the study plots. Infiltration rate for the 3-inch per hour simulated rainfall was almost twice that of the 1.5-inch per hour rainfall (Appendix A).

It was found using variable plots that coppice dunes displayed an exceedingly high infiltration rate i.e., sometimes three to four times greater than the dune interspace areas, and was near or exceeded the application rate. Dune interspace areas exhibit a relative low infiltration rate (Figure 5 through 10). This relationship held true over a wide variety of soils, except for a few Utah juniper coppice dunes where hydrophobic soils were encountered.

TABLE 25. INFILTRATION CAPACITY OF WINTERFAT INTERSPACE AREAS FOR DIFFERENT APPLICATION RATES.

APPLICATION RATE [In/Hr]	INFILTRATION RATE [In/Hr] SOIL INITIALLY DRY	INFILTRATION RATE [In/Hr] SOIL INITIALLY AT FIELD CAPACITY
3.0	0.99	0.26
1.5	0.83	0.34
0.97	0.78	0.48
0.57	0.41[a]	0.20
0.44	0.40[a]	0.28
0.22	0.22[a]	0.20[a]

a/ Infiltration rate not exceeded.

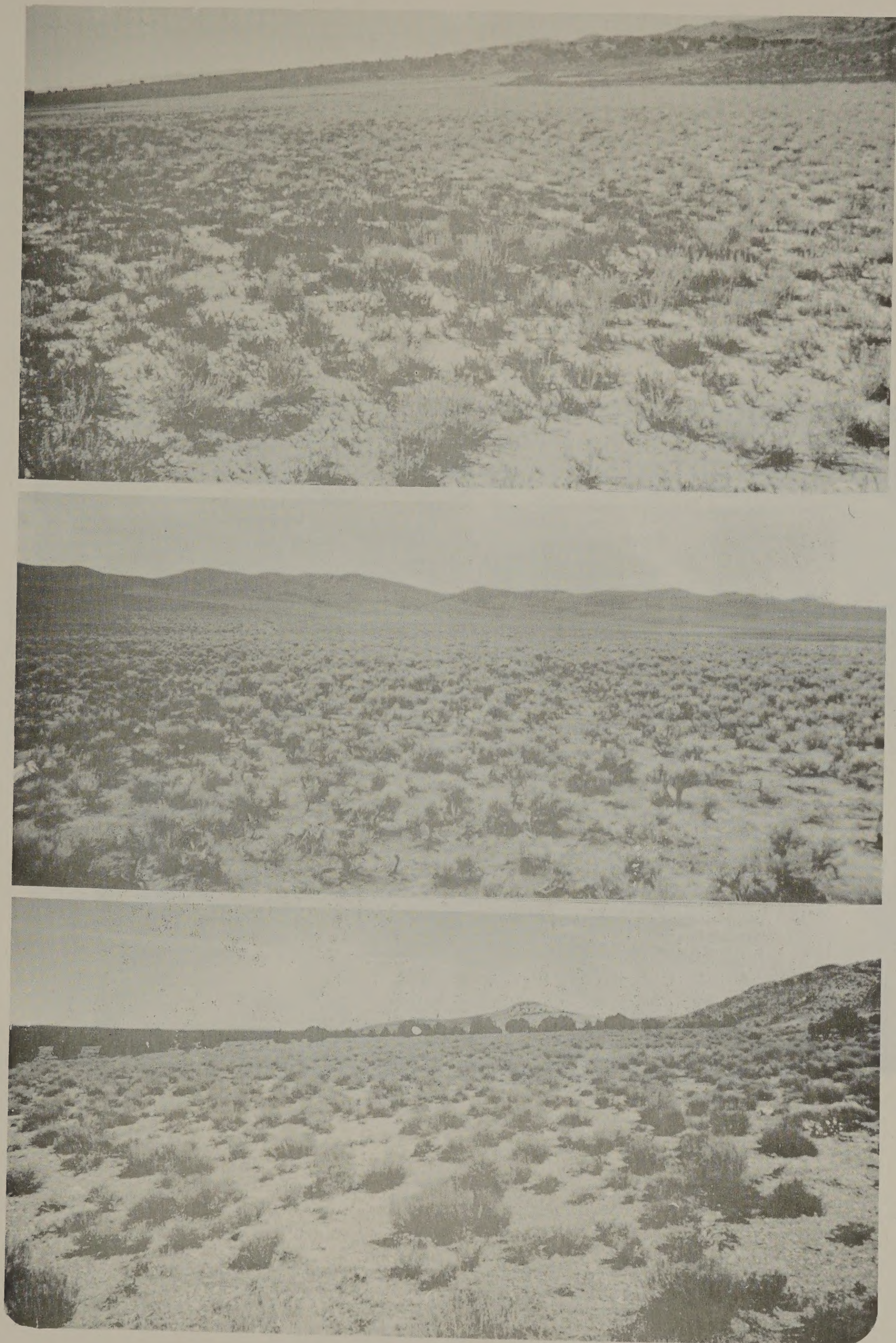


Figure 11. Three plant communities characteristic of the Great Basin showing overstory and sparce vegetation between shrubs.

Figure 12. Coppice dunes and dune interspace areas.

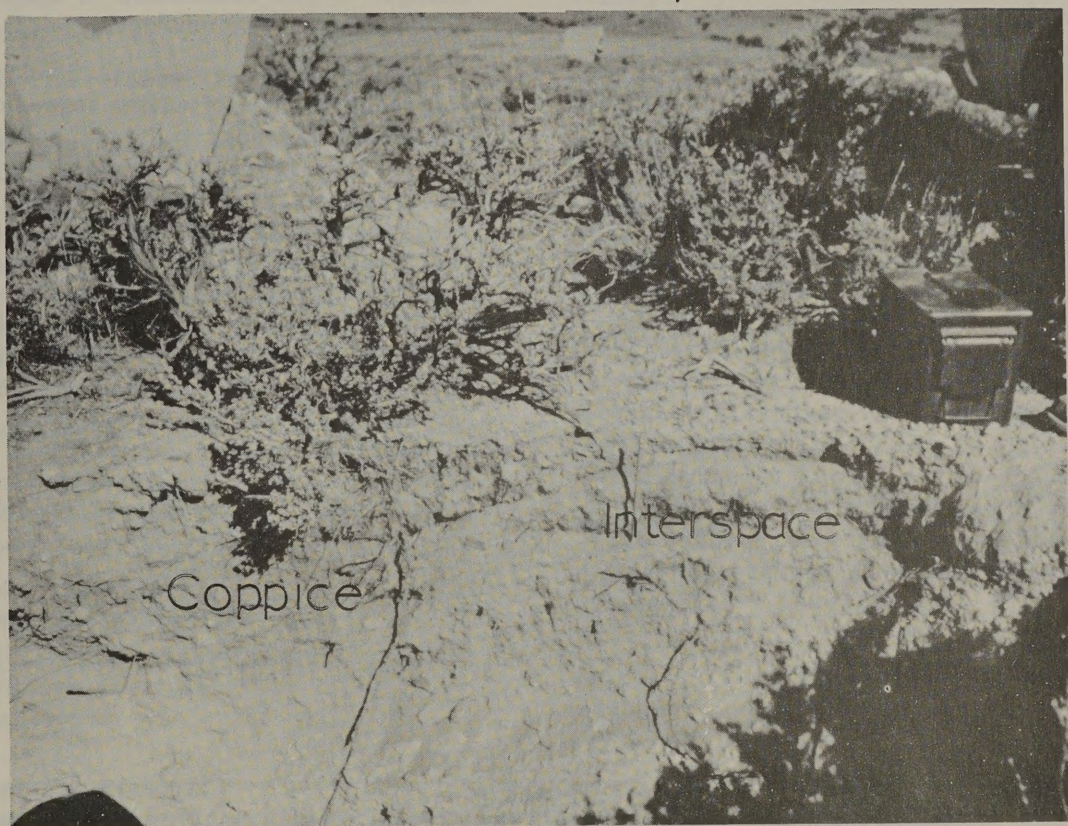


Figure 13. Soil profile showing coppice dune interspace soil surface horizon.

Infiltration rate of soils in dune interspace areas and coppice dunes can be large or small depending on surface horizon morphology of soils in dune interspace areas (Figure 13). The big sagebrush community, Duckwater Watershed, is used to demonstrate this soil difference (Table 26). Dune interspace areas have a shallower surface horizon, a lower percent carbon, a higher pH, a higher bulk density, and a higher percent silt than the coppice dunes. Soil structure in dune interspace areas is moderate for fine platy as compared to weak fine granular in the coppice dunes. Dune interspace areas also have larger and many more vesicular pores in their surface horizon than the coppice dunes. These conditions account for more than three times higher infiltration rates of coppice dunes.

Rate at which water will enter a soil landscape is governed, then, mainly by the extent and soil surface horizon morphology of the dune interspace areas. This relationship is further attested by personal observation of the author after a high intensity thunderstorm at Duckwater Watershed, July 22, 1970. This storm had an average intensity for the basin of 1.2 inches per hour, mostly as hail and rain. However, intensities within the watershed exceeded 4 inches per hour for short periods (John Trimmer, personal communication from records of Bureau of Land Management, Nevada State Office, Reno). Runoff was large, causing major downstream damage to the Duckwater Indian Reservation and to the Watershed (Figures 14 and 15). After the storm, moisture had penetrated more than 8 inches in the coppice dunes and only 2 inches in dune interspace soil (Figure 16).

Vesicular horizon - Infiltration rates are negatively related to vesicular horizons and the strength of this relationship is dependent on vesicular horizon morphology.

Surficial vesicular horizons develop in arid and semiarid areas of sparse vegetation cover. This horizon develops in the soil surface 2 or 3 inches. Soils involved in vesicular development are classified as Aridisols, Torrifluvents or Torriorthents (Table 27) and have low organic matter and high percent silt sized particles. These vesicular horizons are very unstable when nearly saturated, thus accounting for the absence of vesicular porosity in the better aggregated coppice dunes and dune interspace soils. The unstable soil structure, when saturated, accounts for vesicular formation and for a 0.05 to 1 mm thick massive nonvesicular layer to form on the surface. Structure of the vesicular horizon is massive and/or platy (Figure 17). Plates were not

TABLE 26

SOIL SURFACE HORIZON PARAMETERS AND INFILTRATION RATES FOR COPPICE DUNES AND DUNE INTERSPACE AREAS OF THE BIG SAGEBRUSH COMMUNITY, DUCKWATER WATERSHED.

PARAMETER	DUNE INTERSPACE	COPPICE DUNE
Depth	2.0	5.0
Percent Carbon	0.5	1.0
pH	7.7	7.4
Bulk Density (g/cc)	1.8	1.5
Percent Silt	26.0	18.0
Structure	Medium fine platy	Weak fine granular
Pores	Many very fine and fine vesicular	Few fine vesicular and interstitial
Infiltration rate (Inches/Hour)	0.74	2.54

TABLE 27

COPPICE DUNE AND DUNE INTERSPACE SOIL SURFACE STRUCTURE AND PORES FOR THE 28 STUDY SITES

SITE NO.	PLANT COMMUNITY	COPPICE DUNE	DUNE INTERSPACE	SOIL ORDER OR SUBORDER
	DUCKWATER WATERSHED			
1.	*Artemisia nova*	Granular Nonvesicular	Platy Vesicular	Aridisol
2.	*Artemisia Nova/ Artiplex confertifolia*	Granular Slightly Vesicular	Platy Vesicular	Aridisol
3.	*Artemisia tridentata*	Platy Vesicular	Platy Nonvesicular	Aridisol
4.	*Artemisia tridentata/ Chrysothamnus viscidiflorus*	Granular Nonvesicular	Granular Nonvesicular	Aridisol
5.	*Artiplex confertifolia*	Platy Nonvesicular	Platy Nonvesicular	Aridisol
6.	*Artiplex confertifolia/ Eurotia lanata*	Platy Nonvesicular	Platy Vesicular	Aridisol
7.	*Eurotia lanata*	Platy Slightly	Platy Vesicular	Torrifluvent1/
8.	*Juniperus osteosperma*	Granular Nonvesicular	Massive Vesicular	Aridisol
9.	*Pinus monophylla/ Juniperus osteosperma*	Granular Nonvesicular	Single Grain Nonvesicular	Aridisol
	COILS CREEK WATERSHED			
10.	*Artemisia arbuscula/ Poa secunda*	Platy Slightly Vesicular	Platy Vesicular	Aridisol
11.	*Artemisia arbuscula/ Poa secunda*	Granular Nonvesicular	Granular Nonvesicular	Aridisol
12.	*Artemisia tridentata/ Agropyron spicatum/ Balsamorhiza sagittata*	Granular Nonvesicular	Granular Nonvesicular	Aridisol
13.	*Artemisia tridentata/ Poa secunda/ Phlox diffusa*	Platy Slightly Vesicular	Platy Vesicular	Aridisol
14.	*Pinus monophylla/ Juniperus osteosperma Artemisia arbuscula/ Poa secunda*	Granular Nonvesicular	Granular Nonvesicular	Torriorthent1/
15.	*Symphoricarpos longiflorus/ Artemisia tridentata/ Agropyron spicatum/*	Granular Nonvesicular	Granular Nonvesicular	Mollisol

	STEPTOE WATERSHED			
16.	*Artemisia tridentata*	Granular Nonvesicular	Granular Nonvesicular	Aridisol
17.	*Agropyron desertorum*	Granular Nonvesicular	Granular Nonvesicular	Aridisol
18.	*Artemisia tridentata/ Agropyron spicatum*	Granular Nonvesicular	Massive Nonvesicular	Aridisol
19.	*Agropyron desertorum* (high)	Granular Nonvesicular	Granular Nonvesicular	Aridisol
20.	*Artemisia tridentata/ Purshia tridentata/ Agropyron spicatum*	Granular Nonvesicular	Granular Nonvesicular	Mollisol
21.	*Pinus monophylla/ Juniperus osteosperma*	Granular Nonvesicular	Massive Slightly Vesicular	Aridisol
	PINE AND MATHEWS CANYON WATERSHEDS			
22.	*Artemisia tridentata/ Chrysothamnus nauseosus*	Granular Nonvesicular	Massive Slightly Vesicular	Aridisol
23.	*Artemisia tridentata Agropyron desertorum*	Granular Nonvesicular	Granular Nonvesicular	Aridisol
24.	*Juniperus osteosperma*	Granular Nonvesicular	Platy Slightly Vesicular	Aridisol
25.	*Pinus monophylla/ Juniperus osteosperma/ Artemisia nova/ Amelanchier alnifolia*	Massive Nonvesicular	Massive Slightly Vesicular	Aridisol
26.	*Artemisia nova/ Agropyron intermedium*	Massive Nonvesicular	Massive Slightly Vesicular	Aridisol
27.	*Juniperus osteosperma/ Artemisia tridentata/ Sitanion hystrix*	Granular Nonvesicular	Massive Slightly Vesicular	Aridisol
28.	*Juniperus osteosperma/ Agropyron desertorum*	Granular Nonvesicular	Massive Slightly Vesicular	Aridisol

1/ **Entisol suborder**

Figure 14. Flood damage to the Duckwater Indian Reservation's agriculture land (Bureau of Land Management Photograph).

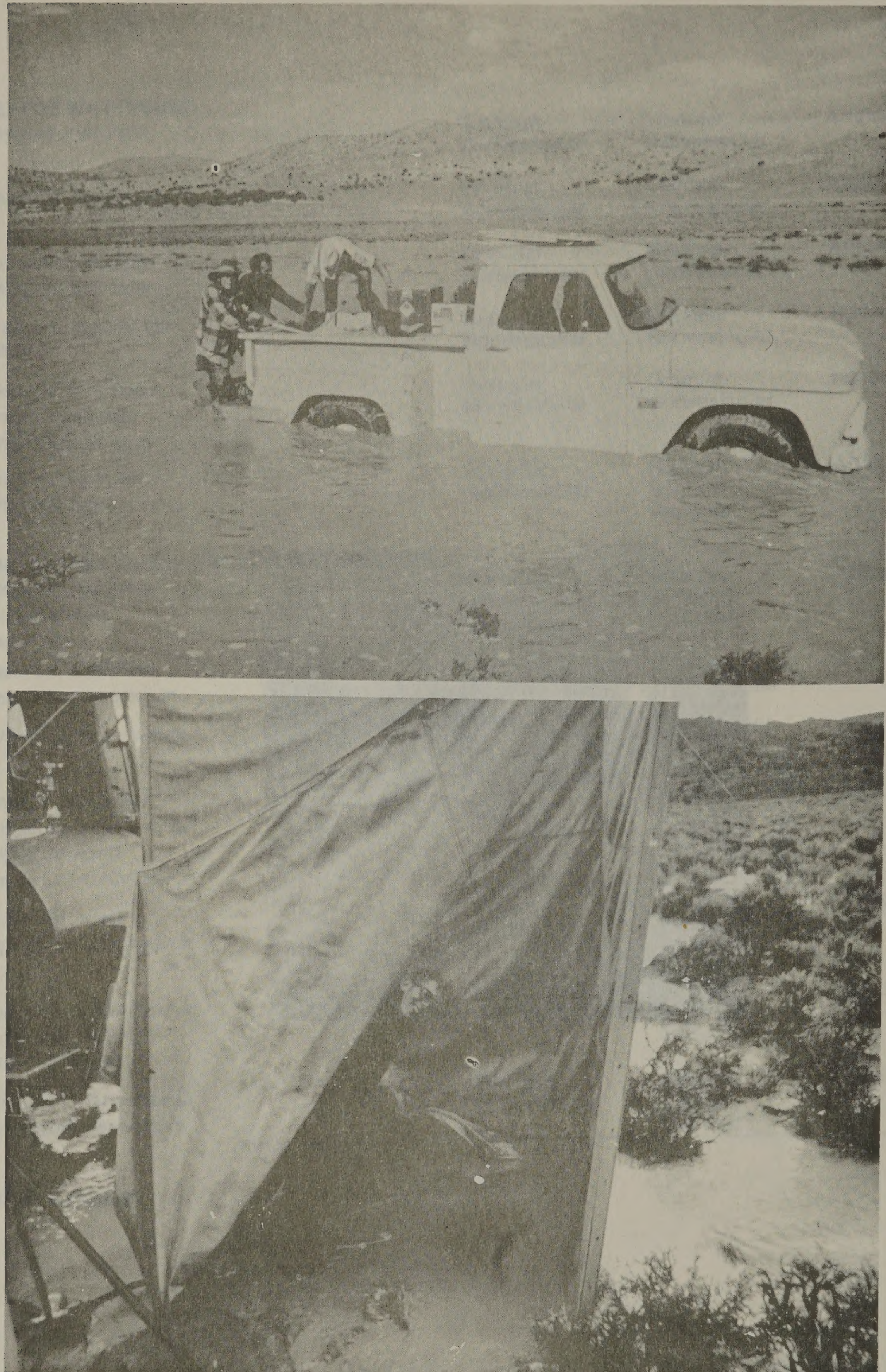


Figure 15. Runoff from high intensity thunderstorm, Duckwater Watershed.

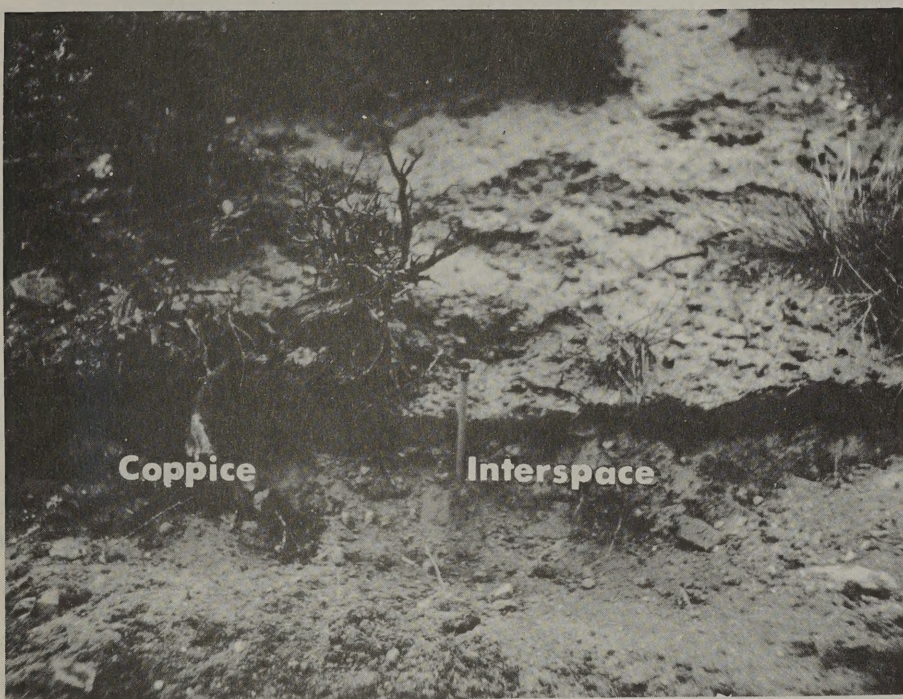


Figure 16. Moisture penetration in coppice dune and dune interspace soil after a high intensity thunderstorm.

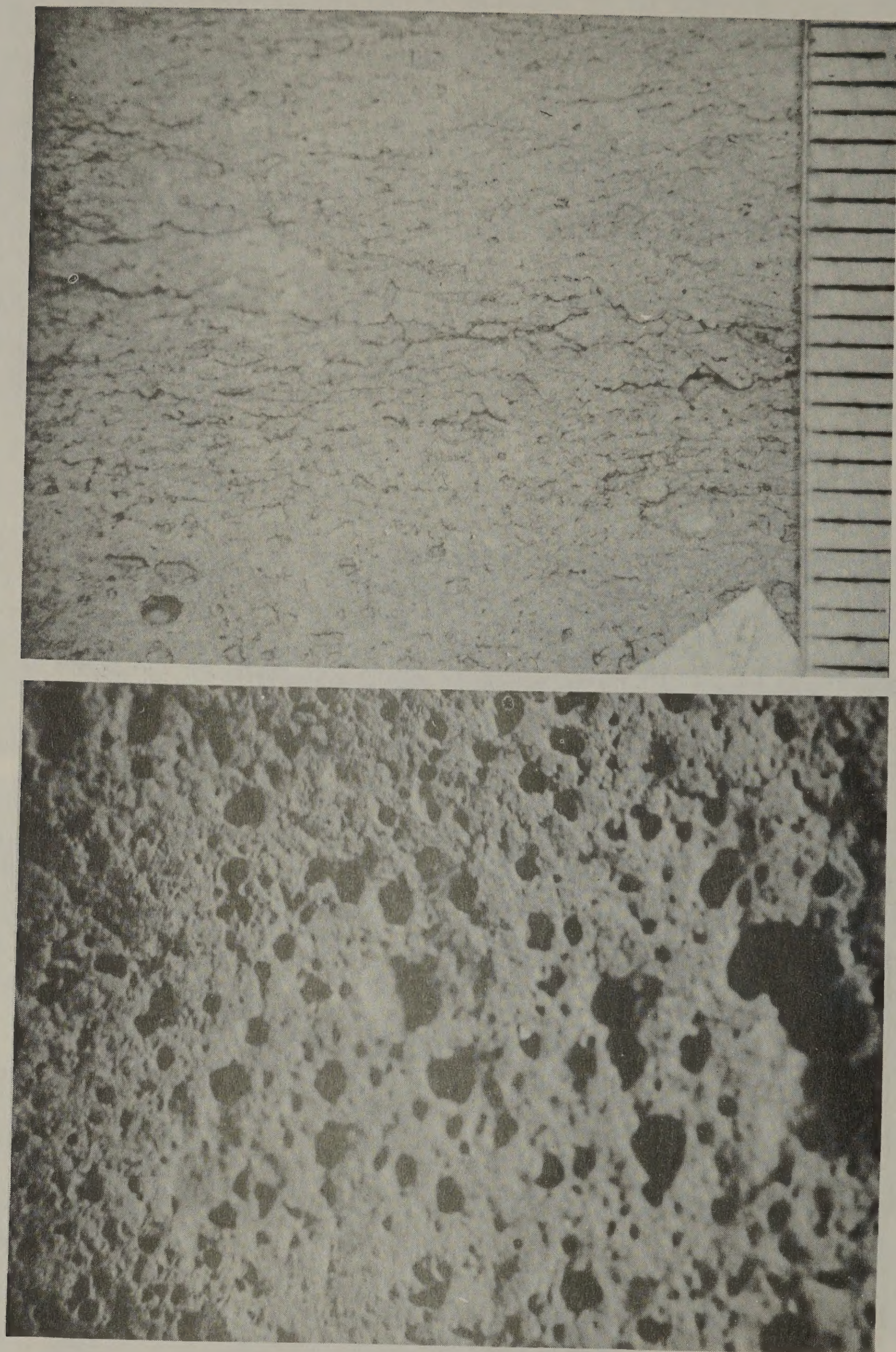


Figure 17. Vesicular horizon showing platy structure and/or vesicular porosity (Scale division is 1 mm). The dark spots in the lower photograph are vesicular pores.

observed in the surface 0.5 inch. Miller (1971) states that platy structure is necessary for vesicular pore formation, however, this is not consistent with field observations by the author. In addition, preliminary research results of the author indicates vesicular horizons may significantly reduce seeding emergence.

Organic matter - Organic matter in the soil is the major agency encouraging aggregation. It not only binds soil particles into aggregates but lightens and expands the soil, thus increasing the porosity and decreasing vesicular horizon formation. Infiltration is positively related to organic matter except for a few juniper coppice dunes where hydrophobic soils occur.

Bulk density - Coppice dunes consistently have a lower bulk density than dune interspace soils. However, dune interspace soils having vesicular porosity exhibit a lower bulk density than dune interspace soils without vesicular porosity. Infiltration rates of soils without vesicular horizons decrease as bulk density increases. Soils that have a vesicular horizon have infiltration rates that decrease as bulk density decreases.

Texture - Silt and clay-sized particles are found to be negatively correlated with infiltration rates whereas sand-sized particles are positively related to infiltration. Generally, the coarser the surface texture, the higher the infiltration rate. Silt is the strongest parameter of the three particle sizes in estimating infiltration.

Surface horizon depth - Thicker surface horizons are found in more productive soils and in coppice dunes, i.e., coppice dunes are 1 to 4-inches thicker than interspace soils. Infiltration rates increase as the surface horizon increases in thickness.

Moisture - Infiltration rate was lower on plots that were initially at field capacity than if initially dry (Appendix A). The higher the initial moisture content the more micropores that are filled and the lower the infiltration rate. Infiltration rates are usually negatively related to initial moisture content except on a few soils where infiltration rates are positively correlated with initial moisture content. Thus soils that are well aggregated have a high water holding capacity and a high infiltration rate.

Plant and litter cover - Plant and litter cover are both important positive parameters influencing infiltration, however, their influence is not as strong as has been shown in other studies (Dortignac and Love, 1961; Rauzi, Fly and Dysterhuis, 1968, Meeuwig, 1970b). In this study, vesicular horizon and dune interspace areas become more important in explaining infiltration than plant and litter cover. This is probably due to the sparse cover of vegetation in the interspace areas and the kind of soils.

Rock - Study sites were characterized by a very low cover of large rocks (>2-inches in largest diameter), thus, rock showed a poor correlation with infiltration. However, as small rocks (1/8 to 2-inches in largest diameter) increased on the sites, infiltration rates decreased. This latter relationship is explained by the large percent of small rocks associated with vesicular horizons.

Bare ground - Infiltration rates were strongly negatively correlated with bare ground. This is consistent with findings of Duley and Domingo, (1949), Branson and Qwen, (1970), and many others.

Slope - Percent slope shows a positive correlation with infiltration rates indicating that as slope increases so does infiltration rate. However, slope actually has very little influence on infiltration rates. Most study sites are characterized by very gentle slopes except for a few in the mountains where sites on steeper slopes also have high infiltration rates. The correlation, then, is due to different soils and not to slope.

Surface roughness - Surface roughness shows a weak positive correlation with infiltration, thus indicating an irregular surface may increase infiltration rates slightly. This poor correlation is probably due to the fairly level relief of the study areas.

Hydrologic groups - Hydrologic groups as first developed by Musgrave, (1955) and later modified by Ogrosky and Mockus, (1964) are based on texture, drainage, impeding strata and that soils are classified on basis of intake of water at the end of long-duration storms occurring after prior wetting and opportunity for swelling and without the protective effects of vegetation. Hydrologic group classifications show very poor relationship with actual field tests. For example, based on group descriptions, a soil classified as B hydrologic group (Figure 18) has a much lower infiltration rate than soils clas-

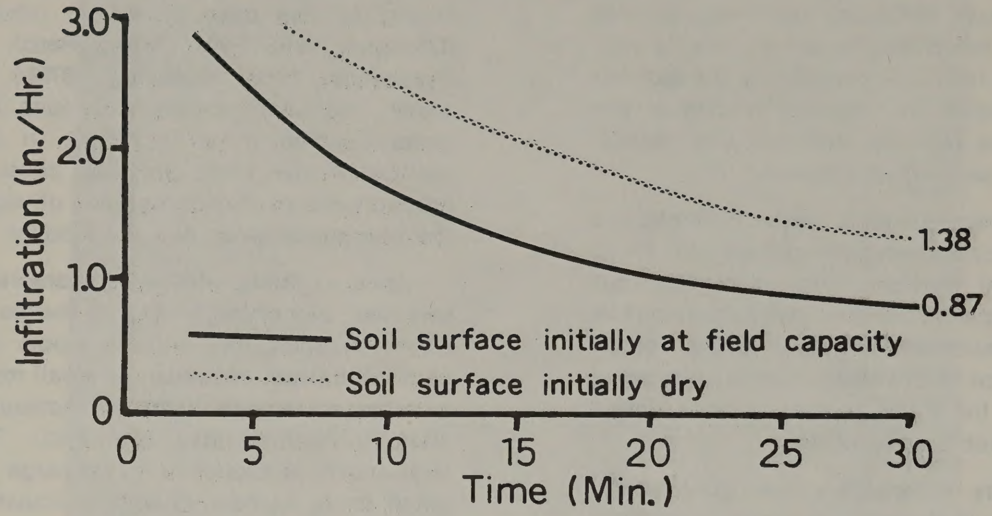


Figure 18. Infiltration curves for the *Eurotia lanata* community, Duckwater Watershed, B hydrologic group.

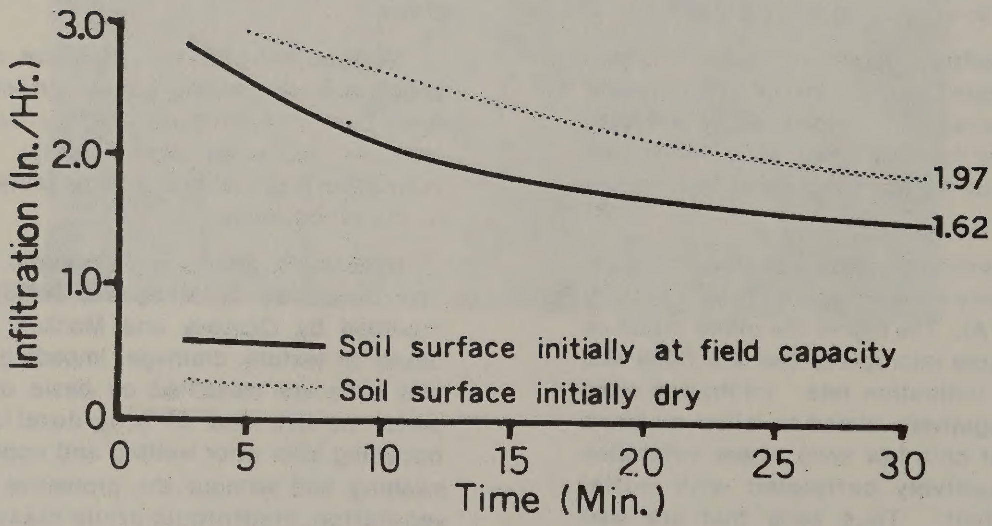


Figure 19. Infiltration curves for the *Artemisia arbuscula/ Poa secunda* community, Coils Creek Watershed, D hydrologic group.

sified as D hydrologic group (Figure 19). The B hydrologic group soil, although sandy loam throughout and without impeding strata, has a strong vesicular horizon in the dune interspace soil. Hydrologic groups are based on several assumptions that do not hold true for the arid West: (1) that texture and impeding strata are the important factors governing infiltration; (2) that vegetation is not important; (3) that intake rates should be based on a long duration storm after prior wetting; and (4) that epipedon properties are not important.

Impeding strata had very little effect on infiltration rates. This goes along with the findings of Duley and Kelly, (1939). Soil surface in the interspace between shrubs have the greatest influence on infiltration. Infiltration rates show the strongest correlation with silt size particles. It is doubtful that very much of the negative rangeland will be plowed, at least not for a long time. Thus infiltration rates should be determined in their unplowed condition, not in some artificial condition without vegetation. Runoff problems in the arid West very seldom occur with spring runoff when soils are thoroughly wetted, but in summer by high intensity short duration thunderstorms on dry soils (Osborn and Hickok, 1968; Osborn and Renard, 1969).

Using criteria in the new soil classification system (USDA, 1970) as suggested by Chiang and Peterson (1970) just amplify the same basic problems of using subsurface texture and restrictive layer in estimating infiltration. The new classification system assumes all soils are or will be plowed and thus uses mostly subsurface criteria to classify soils. It fails to provide a means of classifying surface soil conditions which are the major controlling factors of infiltration.

Results of this study demonstrate that hydrologic groups give a very poor estimate of infiltration rates on arid rangeland and that trying to modify them just creates more problems. These groups should be abandoned for use in estimating infiltration rates in the arid and semiarid west and criteria developed using surface soil characteristics.

Factors Influencing Sediment Production

Most of the sediment comes from dune interspace areas. As dune interspace areas increase, sediment production increases. Similar relationships also are observed for percent bare ground and percent silt.

Significantly more sediment is produced from soils initially at field capacity than those initially dry. This is due to instability of the surface horizon when saturated. The soil surface reaches saturation quicker on the wet test, thus having a longer time to erode the dispersed soil particles. In this way, initial moisture content shows a positive correlation with sediment. This relationship is most marked for soils having a vesicular surface horizon.

As organic matter, sand size particles, coppice dunes, and litter increase on the study sites, sediment production decreases. Plant cover or plant and litter cover show poor correlation with sediment production and do not appear in regression equations. Roughness factor is slightly negatively correlated with sediment production. As bulk density of the surface 4 inches increase, sediment production usually increases, except on sites having vesicular horizons where bulk density is negatively related to sediment production.

The large variation in sediment production can be explained by: the gentle slopes which allow soil particles that have been detatched and suspended to settle out in the small depressions before they reach the collection trough, and location of coppice dunes and dune interspace areas. Coppice dunes have a lower rate of sediment production than dune interspace areas. Thus, the amount of coppice dune in the plot, if not constant, would influence sediment production. Likewise, suspended sediment was seen to settle out along the coppice dune edge. This effect was magnified the closer the coppice dune was to the collection trough.

SUMMARY AND CONCLUSIONS

Infiltration rates and sediment production were studied on 28 plant communities and soils in central and eastern Nevada. Two rainfall intensities were simulated, 1.5-inch per hour for 60 minutes duration and 3-inch per hour for 30 minutes duration. Two soil moisture conditions were used, soil initially dry and initially at field capacity. Field and laboratory investigations revealed the following:

Noth. new

1. Substantially higher infiltration rates were observed on coppice dunes than on dune interspace areas. Thus, the extent and morphology of the dune interspace surface soil essentially control infiltration rates of the various soils.

2. Infiltration rates for the various plant communities and soils vary considerably within watersheds and between watersheds. Soils within the Steptoe Watershed generally have the highest infiltration rates, and the Duckwater Watershed soils generally exhibit the lowest infiltration rates. However, the variation is high between plant communities, for example, within Duckwater Watershed the pinyon-juniper community has the highest infiltration rate and the winterfat community the lowest rate of all sites studied.

3. The two plant communities within Steptoe Watershed that were plowed and drilled to crested wheatgrass show no significant difference nor apparent trend in infiltration rates as compared with their untreated counterparts. Three plant communities, however, at Pine and Mathews Canyon Watersheds that were railed and seeded or chained and seeded show a trend of higher infiltration rates for treated sites as compared to untreated counterparts. Of the three treated communities only the older treatment that was railed and seeded in 1954 shows a significantly higher infiltration rate than its untreated counterpart. These results point out that it takes time for a vegetation conversion treatment to significantly affect infiltration rates and if dune interspace soil surface is well aggregated and free of cesicular horizon before treatment, there may never be a significantly larger infiltration rate realized for the treated site.

Noth. new

4. Most of the sediment comes from dune interspace areas rather than from coppice dunes. Thus, the extent and morphology of dune interspace surface essentially controls sediment production.

   Significantly, more sediment is produced from soils that are initially at field capacity than those that are initially dry. This is due to the instability of surface soils when saturated. The surface soil reaches saturation quicker on soils initially at field capacity, thus having a longer time to erode dispersed soil particles. Sediment production, like infiltration rates, varies considerably for the plant communities and soils within and between watersheds. Soils at Duckwater Watershed generally produced the largest quantities of sediment. Lower sediment production occurs from Steptoe, Pine and Mathews Canyon Watersheds.

5. The two plant communities within Steptoe Watershed that were plowed and drilled to crested wheatgrass show no significant difference nor trend in sediment production from their unseeded counterparts. The three units at Pine and Mathews Canyon Watersheds that were railed and seeded or chained and seeded show a trend of smaller sediment quantities than their untreated counterpart, however, there are no significant differences.

Noth. new

6. Infiltration rates and sediment production of the various soils are largely controlled by dune interspace extent and its soil surface morphology. Vesicular horizons are found unstable in dune interspace surface soils but seldom occur in coppice dunes or in well aggregated dune interspace soils. Infiltration rate is negatively related to occurrence of a vesicular horizon and its morphology.

Noth. new

7. Infiltration rates are positively related to organic matter content of the soil surface horizon except for a few juniper coppice dunes where hydrophobic soils occur.

8. Coppice dunes consistently have a lower bulk density than dune interspace soils. Dune interspace soils having a vesicular surface horizon have a lower bulk density than dune interspace soils without a

vesicular horizon. Soils without surface vesicular horizons have infiltration rates that decreases as bulk density increases. However, soils that have a surface vesicular horizon have infiltration rates that decrease as bulk density increases.

9. Infiltration rates decrease as percent silt and clay size particles increase in the soil surface horizon but infiltration rates increase as percent sand size particles increase. Of these three parameters, percent silt shows the strongest correlation.

10. Infiltration rates increase as the soil surface horizon increases in thickness. Infiltration rates are lower for soils that are initially at field capacity than if initially dry. Infiltration rates are usually negatively related to initial moisture content except on a few soils that exhibit fairly high infiltration rates and have a high initial moisture content.

11. Plant and litter cover are both important parameters influencing infiltration, however, their influence is not as strong as vesicular horizons and dune interspace areas. Infiltration rates show a strong correlation with bare ground, but poor correlations are shown with rock, slope and surface roughness.

12. As organic matter, sand size particles, coppice dunes and litter increase, sediment production decreases. Roughness factor is slightly negatively correlated with sediment production. As bulk density on the surface 4 inches increases, sediment production usually increases, except for soils having vesicular horizons where bulk density is negatively related to sediment production.

13. Soil hydrologic groups as now described give a very poor estimate of infiltration rates and trying to modify them just creates more problems. These groups should be abandoned for use in estimating infiltration rates of arid and semiarid rangeland and criteria should be developed using surface soil characteristics. For example, a possible classification of a soil's in-place infiltration rate based on dune interspace surface soil characteristics could be as follows:

    A. (High infiltration capacity) sandy surface texture or well aggregated granular structure without vesicular pores.

    B. (Moderate infiltration capacity) massive or weak platy structure with few to common vesicular pores.

    C. (Slow infiltration capacity) moderate platy structure with common vesicular pores, massive with many vesicular pores, or clayey and weakly structured.

    D. (Very slow infiltration capacity) strong platy structure with many vesicular pores or clayey and massive

14. A more quantitative approach would be to determine for a watershed the variables that appear in a chosen regression equation, then use the equation to determine infiltration rates.

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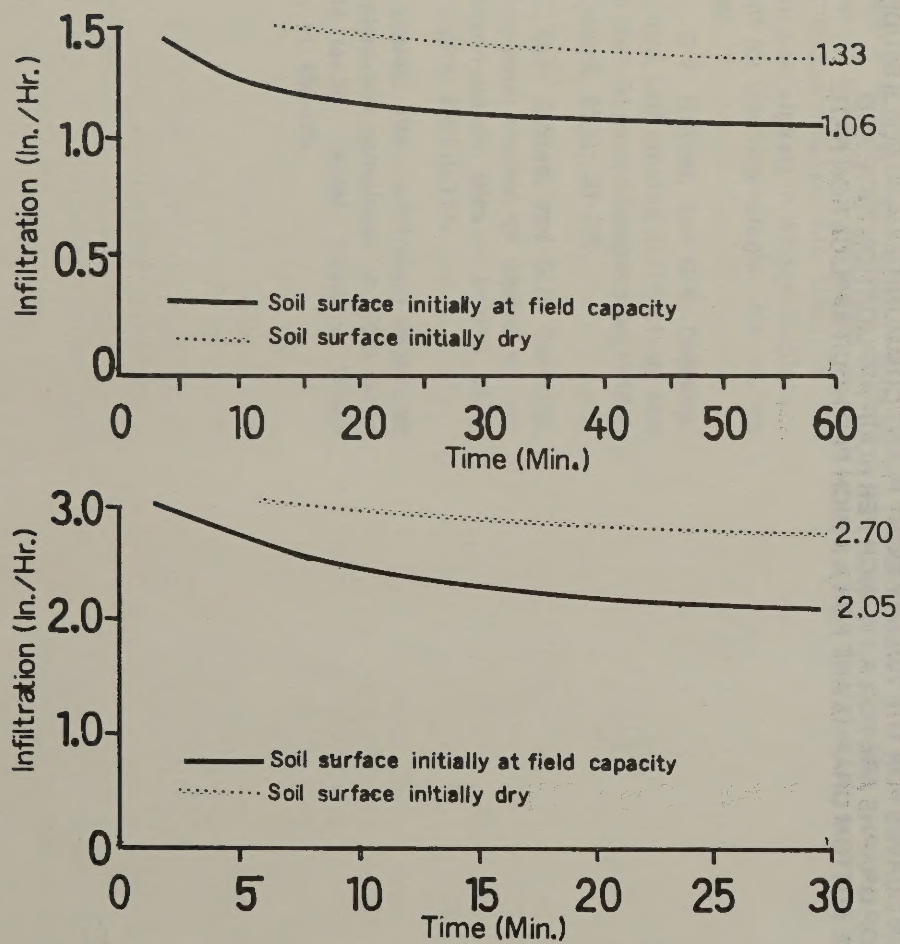
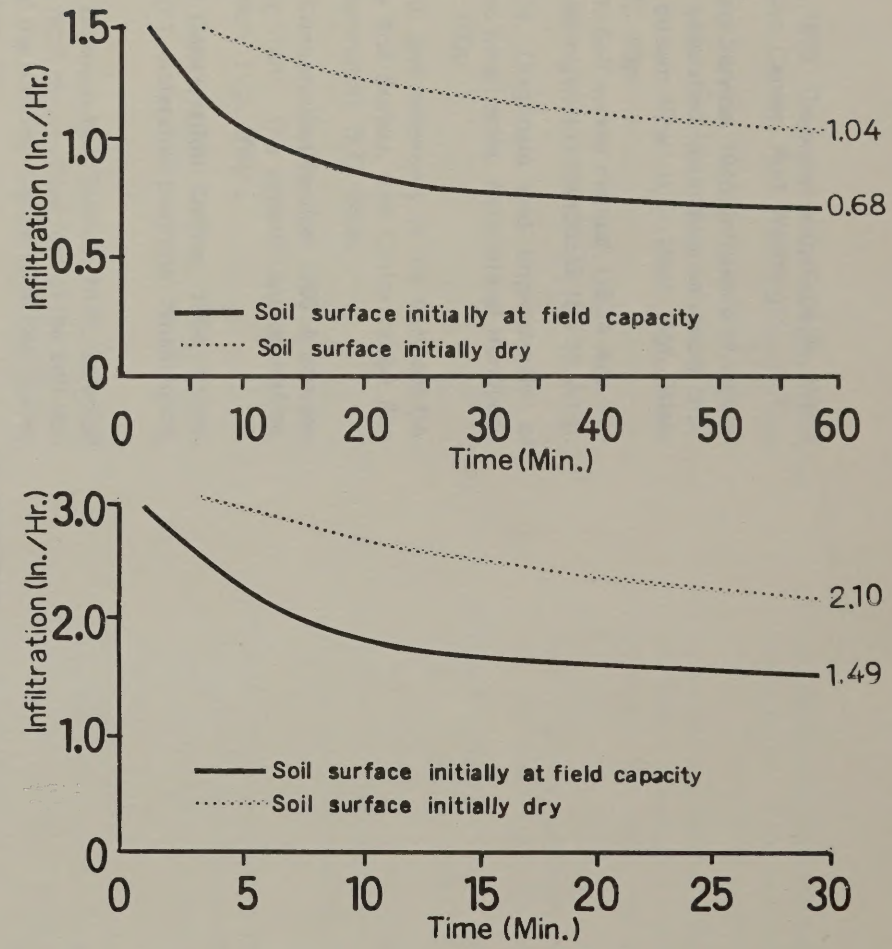
APPENDIX A.

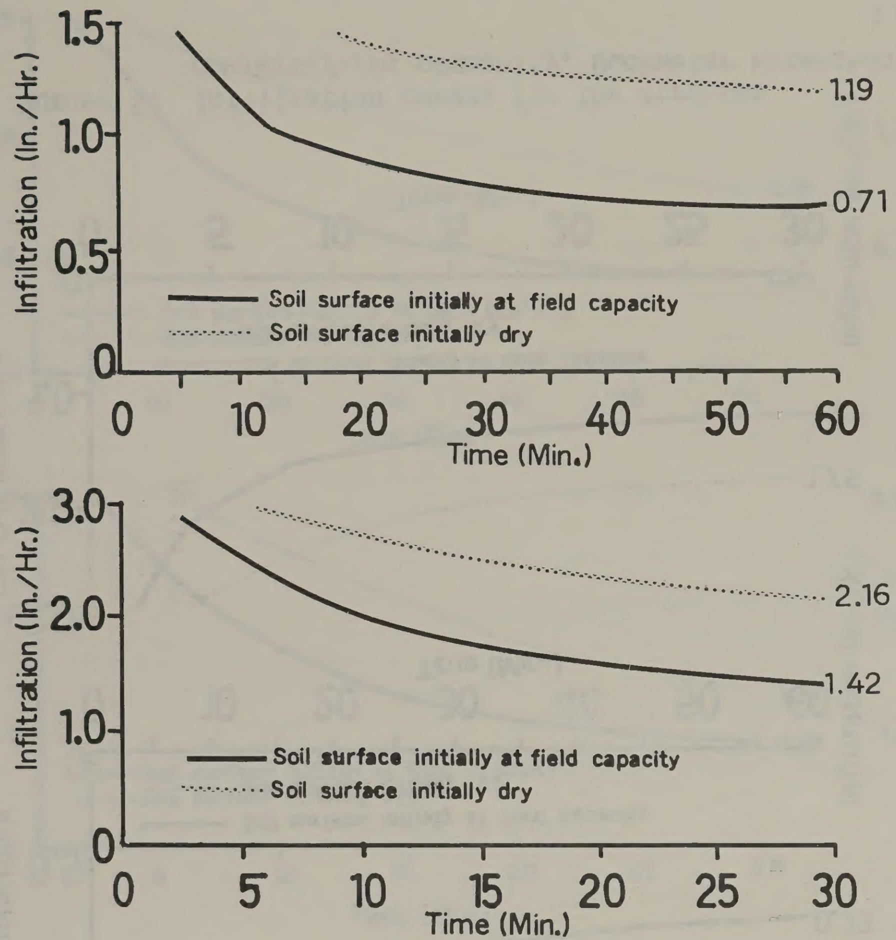
INFILTRATION CURVES FOR THE TWENTY EIGHT PLANT COMMUNITIES AND SOILS STUDIED. TOP GRAPHS ARE FOR A 1½-INCH PER HOUR APPLICATION RATE AND THE BOTTOM GRAPHS ARE FOR A 3-INCH PER HOUR APPLICATION RATE.



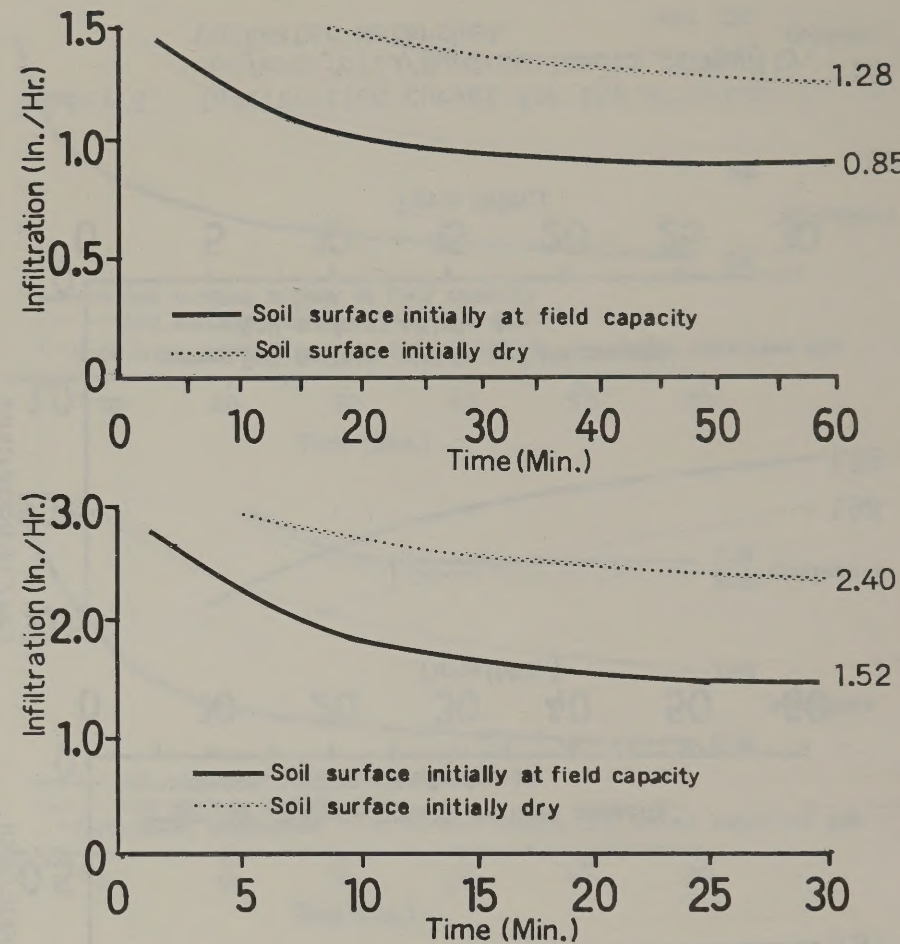
Number 1. Infiltration curves for the *Artemisia nova* community, Duckwater Watershed.



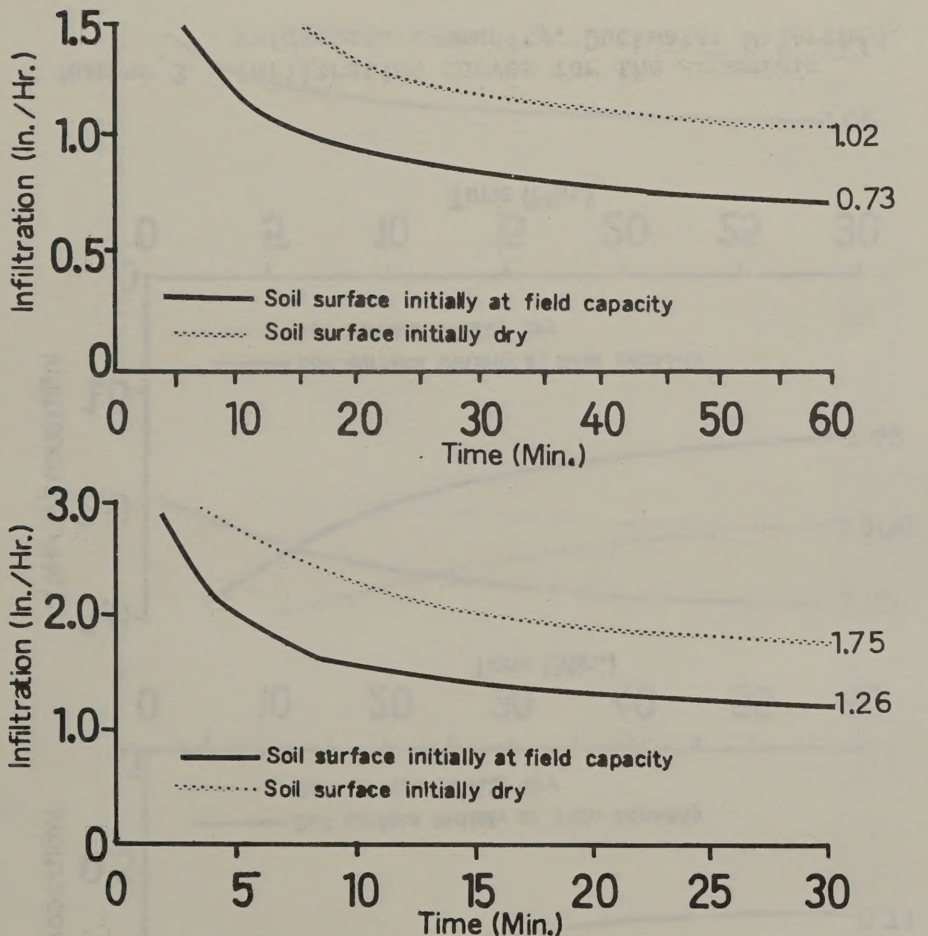
Number 2. Infiltration curves for the *Artemisia nova/Atriplex confertifolia* community, Duckwater Watershed.



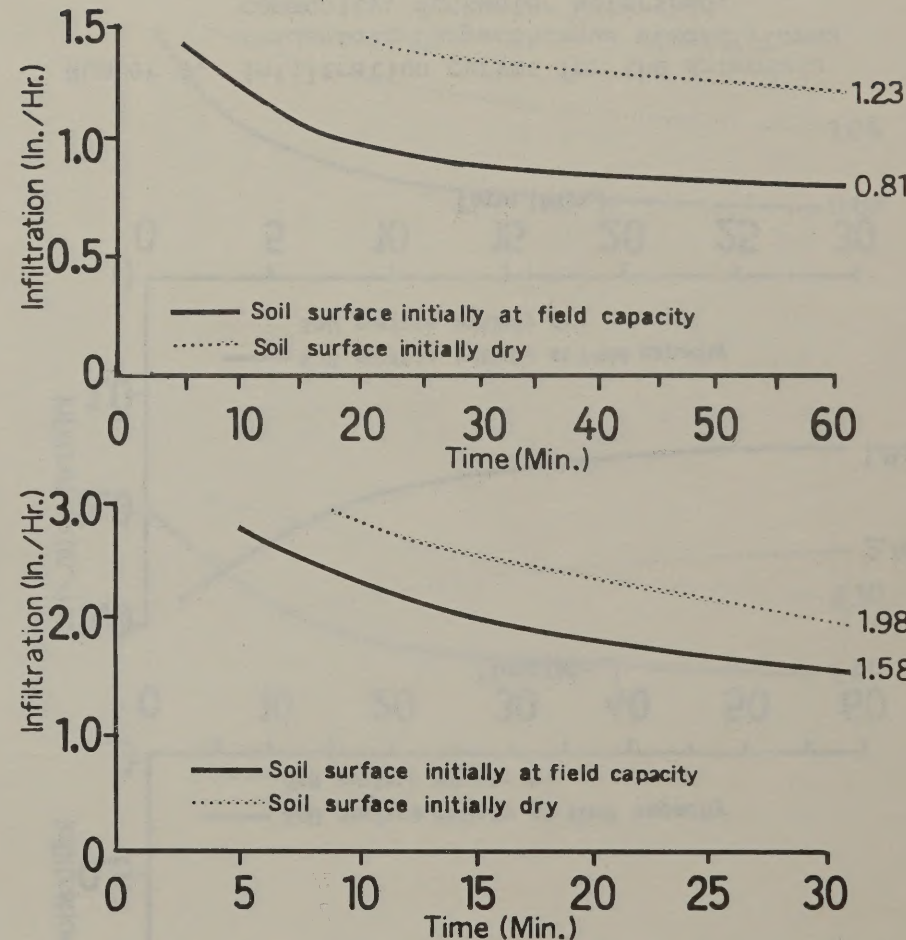
Number 3. Infiltration curves for the *Artemisia tridentata* community, Duckwater Watershed.



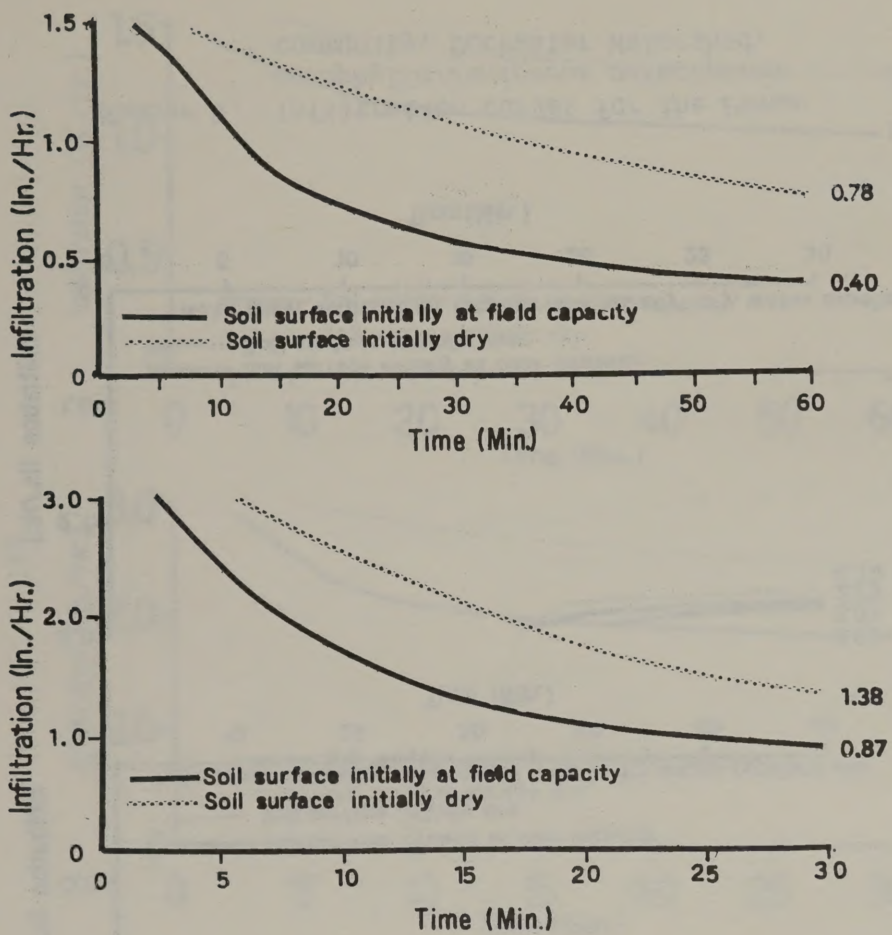
Number 4. Infiltration curves for the *Artemisia tridentata/Chrysothamnus viscidiflorus* community, Duckwater Watershed.



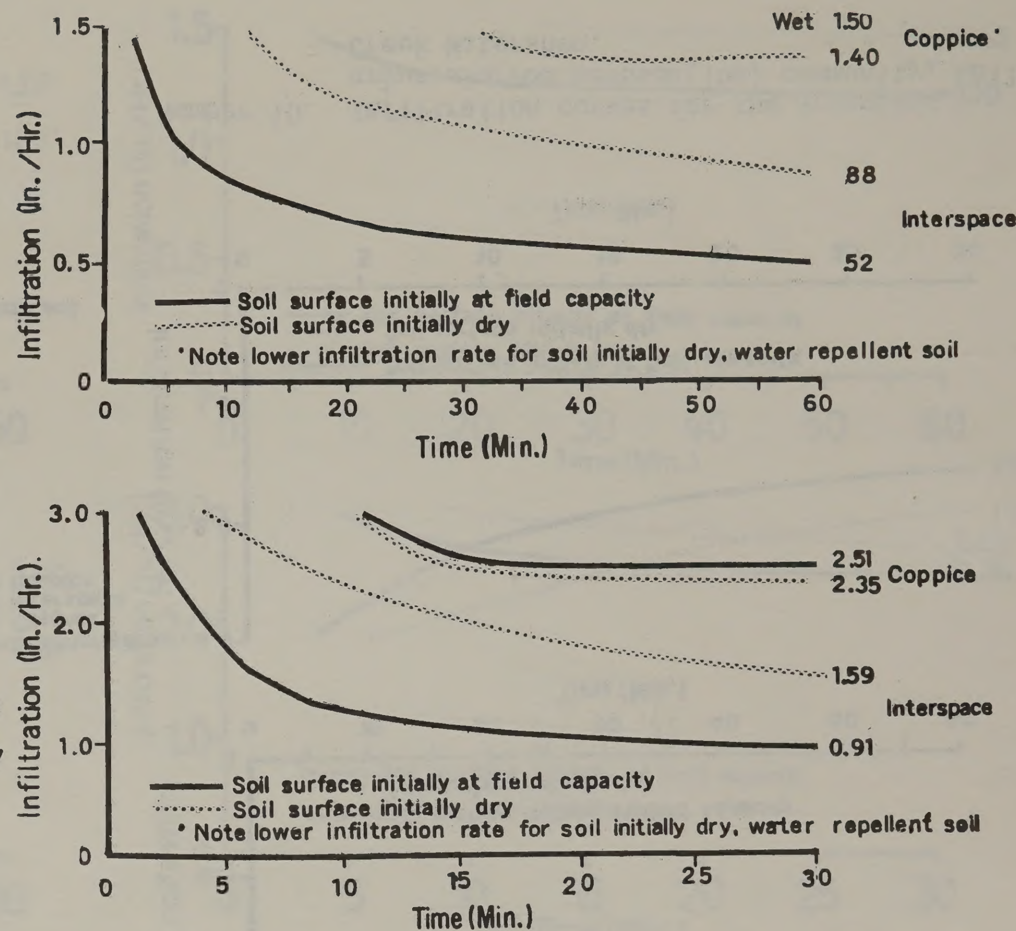
Number 5. Infiltration curves for the *Atriplex confertifolia* community, Duckwater Watershed.



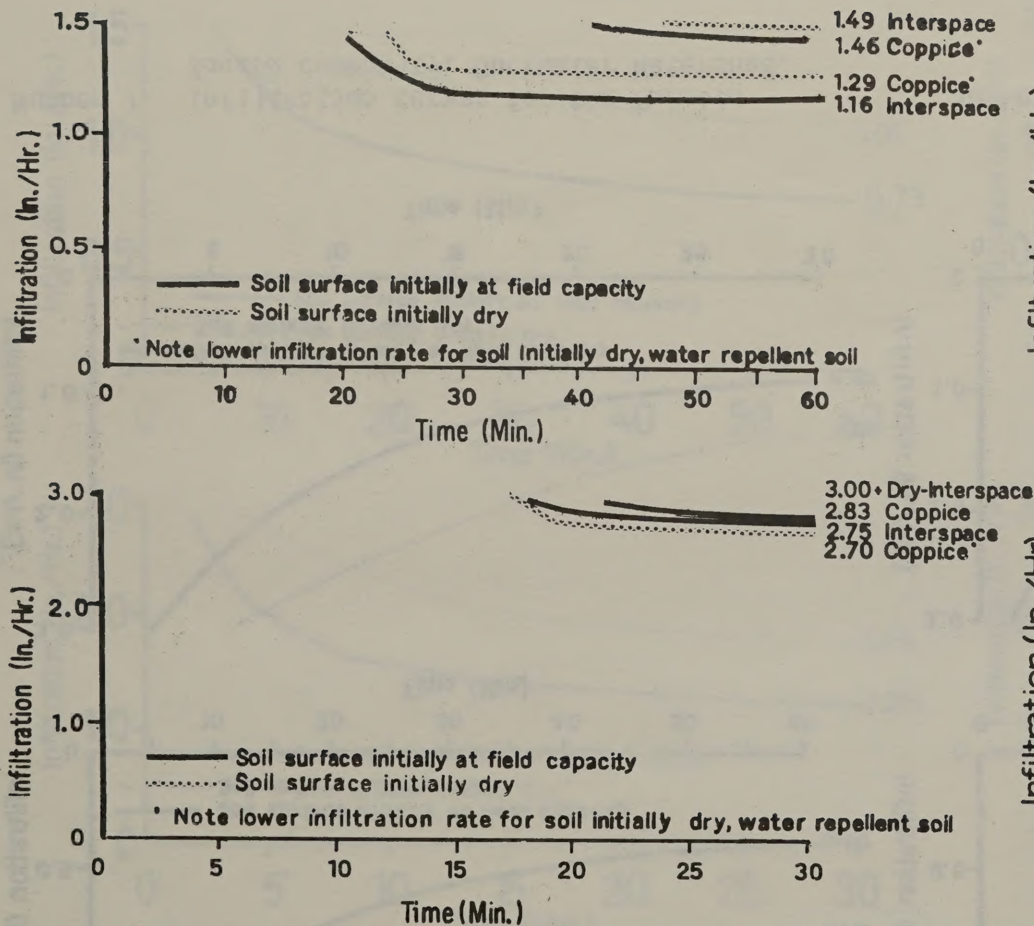
Number 6. Infiltration curves for the *Atriplex confertifolia/Eurotia lanata* community, Duckwater Watershed.



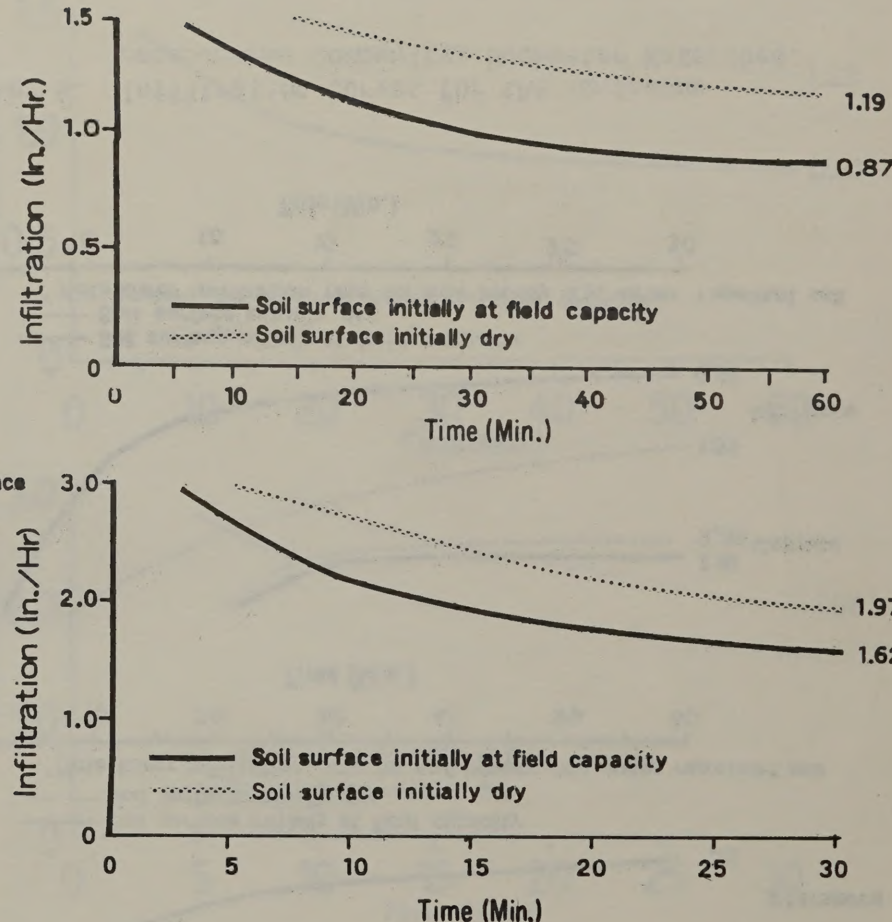
Number 7. Infiltration curves for the *Eurotia lanata* community, Duckwater Watershed.



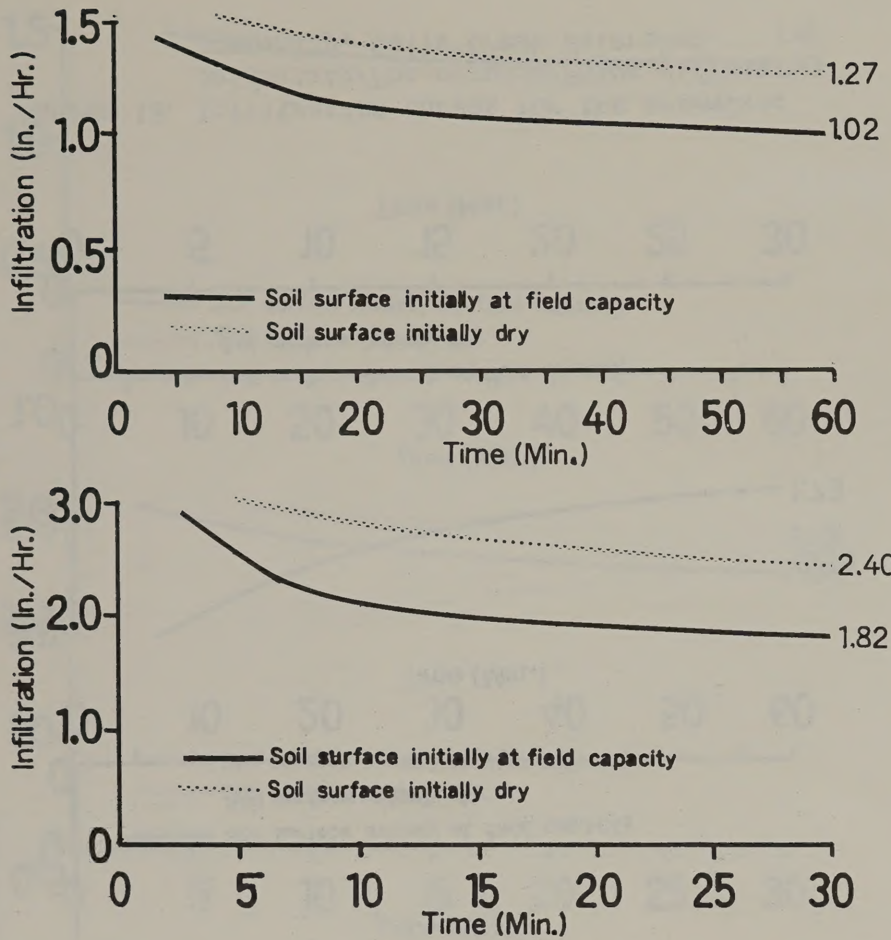
Number 8. Infiltration curves for the *Juniperus osteosperma* community, Duckwater Watershed.



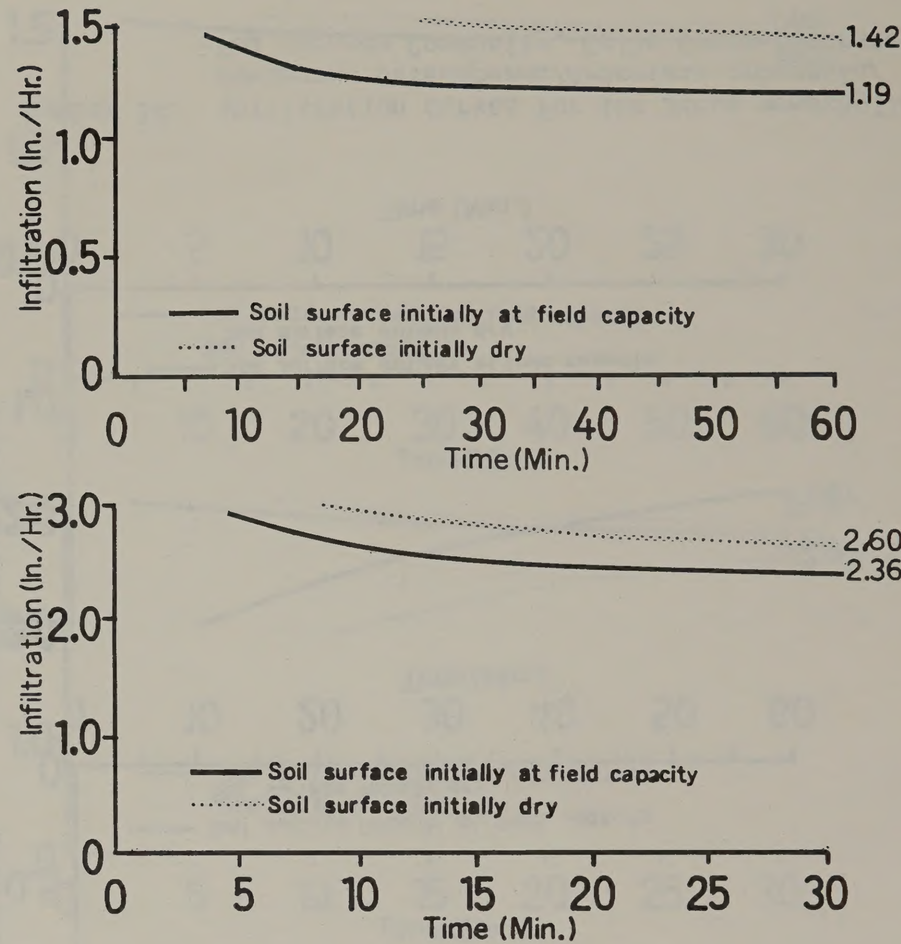
Number 9. Infiltration curves for the *Pinus monophylla/Juniperus osteosperma* community, Duckwater Watershed.



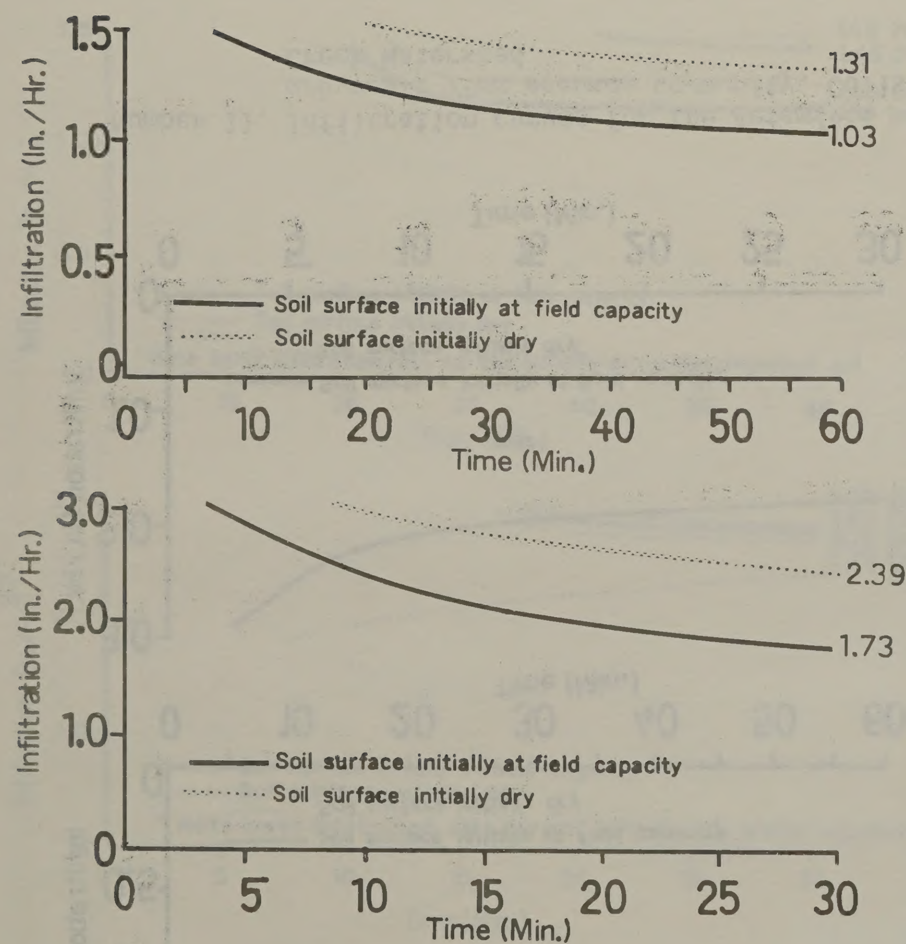
Number 10. Infiltration curves for the *Artemisia arbuscula/Poa secunda*(low) community, Coils Creek Watershed.



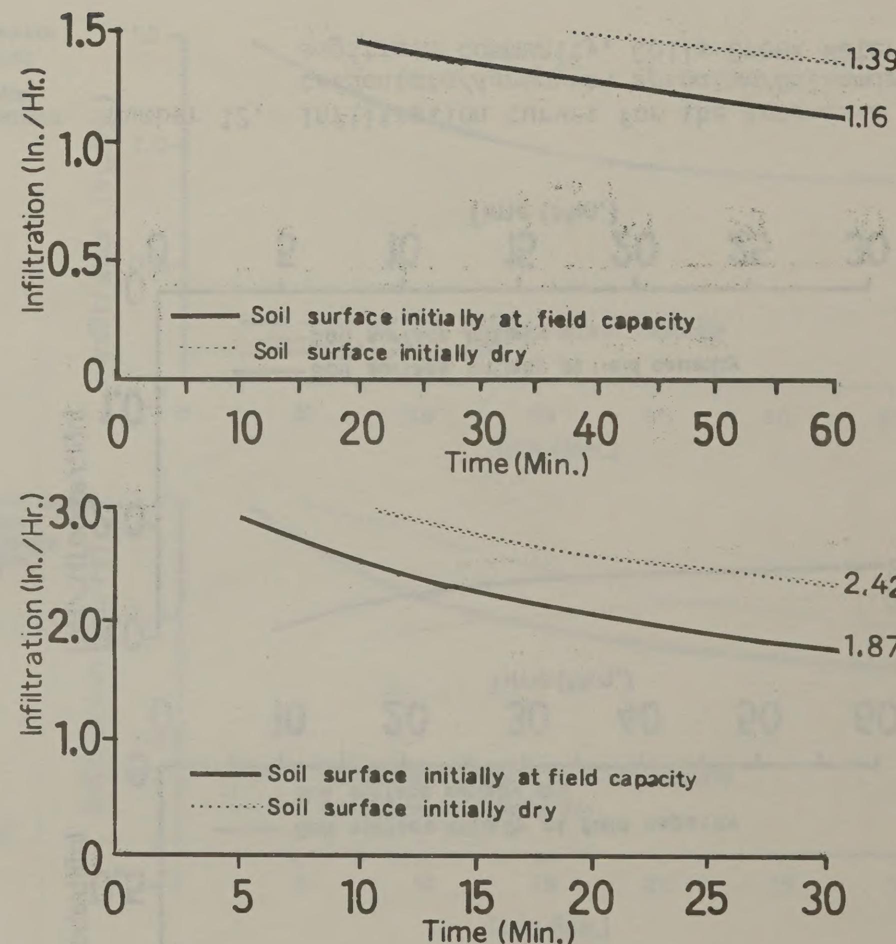
Number 11. Infiltration curves for the *Artemisia arbuscula /Poa secunda* community, Coils Creek Watershed.



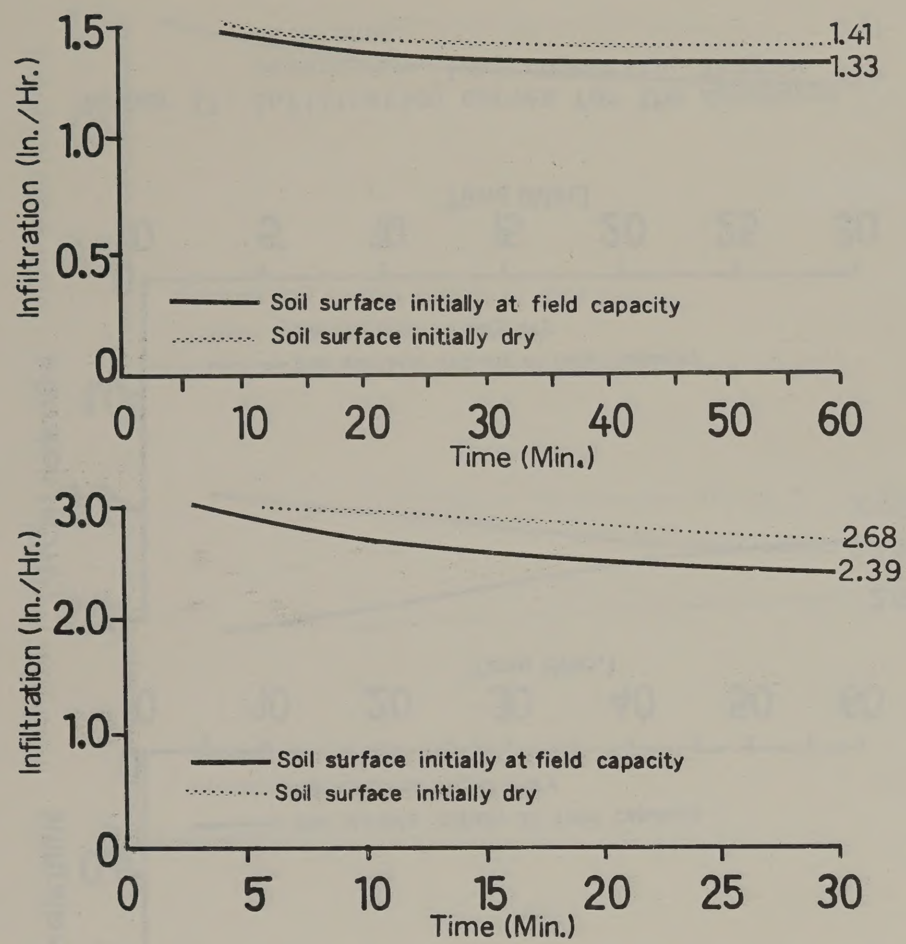
Number 12. Infiltration curves for the *Artemisia tridentata/Agropyron spicatum/Balsamorhiza sagittata* community, Coils Creek Watershed.



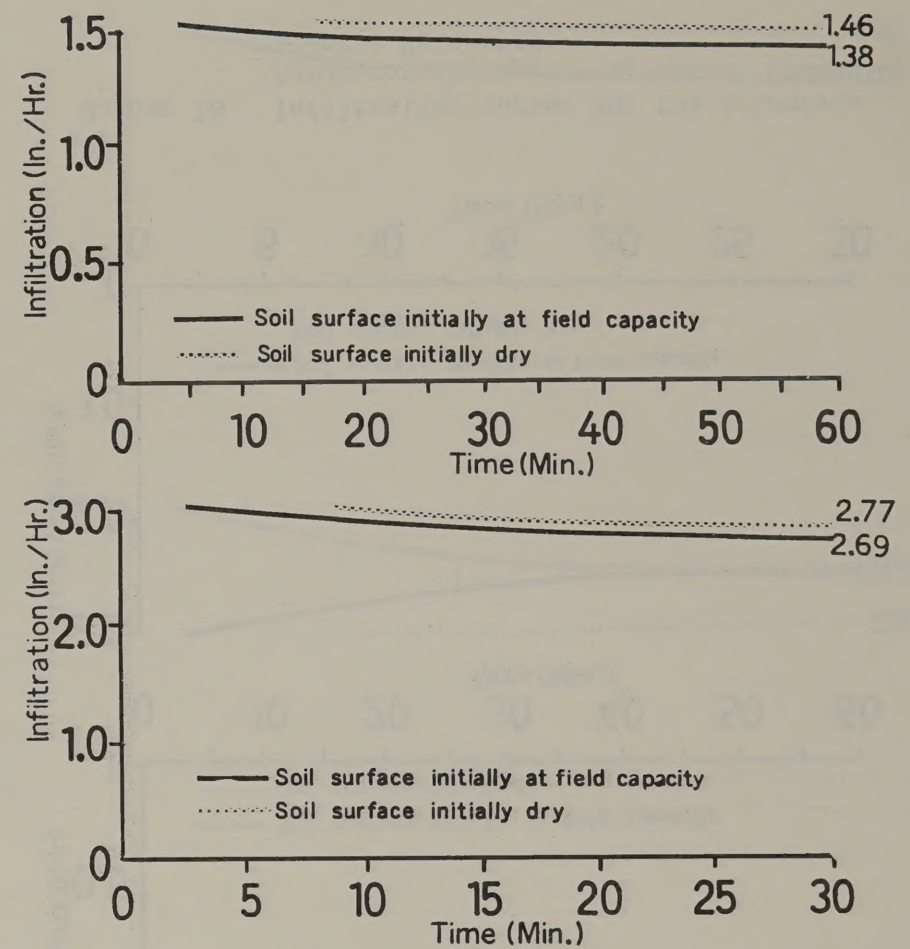
Number 13. Infiltration curves for the *Artemisia tridentata/Poa secunda/Phlox diffusa* community, Coils Creek Watershed.



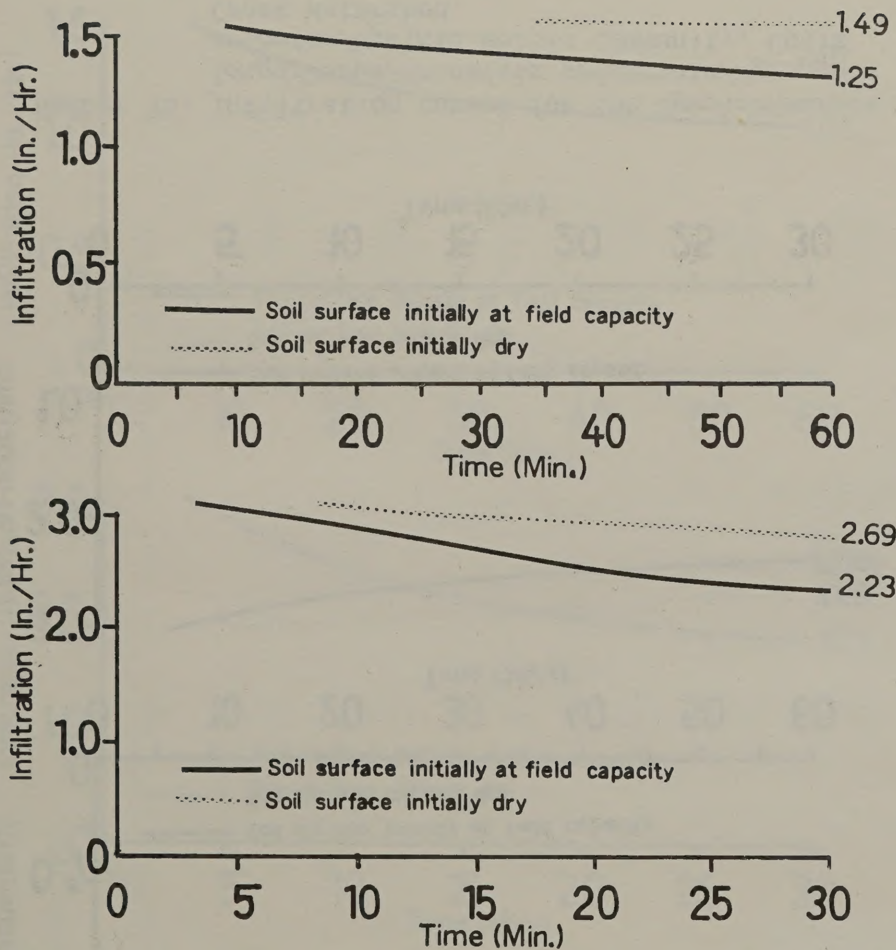
Number 14. Infiltration curves for the *Pinus monophylla/Juniperus osteosperma/Artemisia arbuscula/Poa secunda* Community, Coils Creek Watershed.



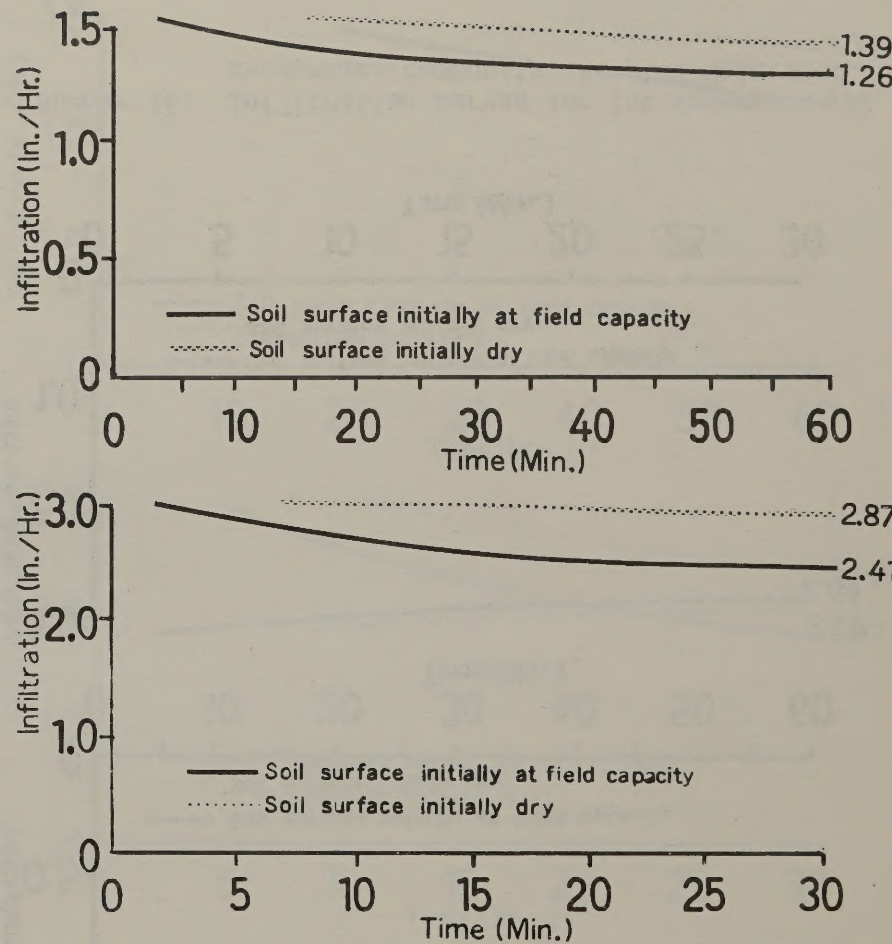
Number 15. Infiltration curves for the *Symphoricarpos longiflorus/Artemisia tridentata/Agropyron spicatum/Wyethia mollis* community, Coils Creek Watershed.



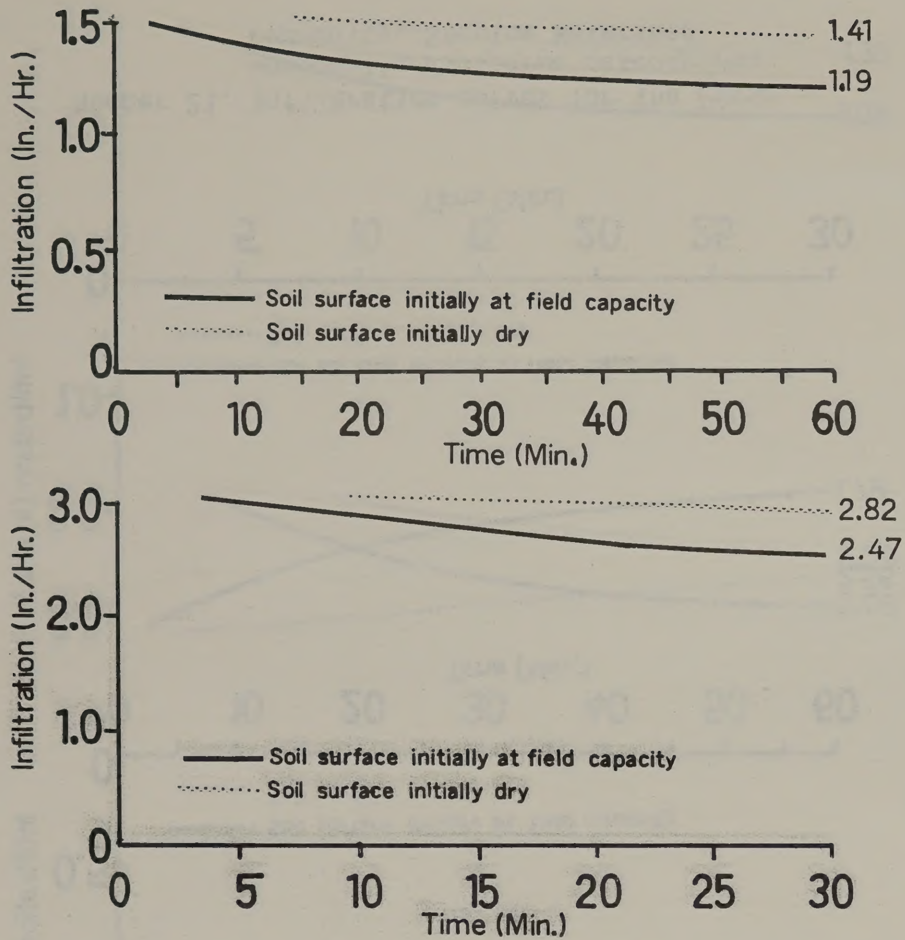
Number 16. Infiltration curves for the *Artemisia tridentata* community, Steptoe Watershed.



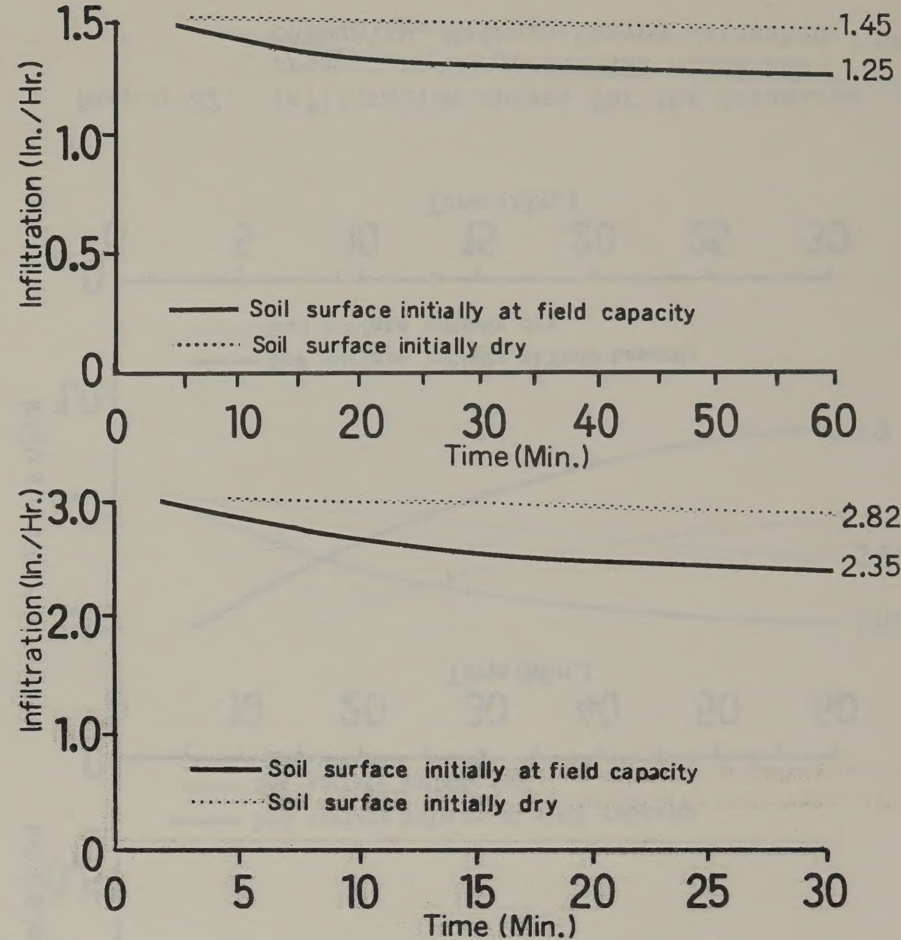
Number 17. Infiltration curves for the *Agropyron desertorum* (low) community, Steptoe Watershed.



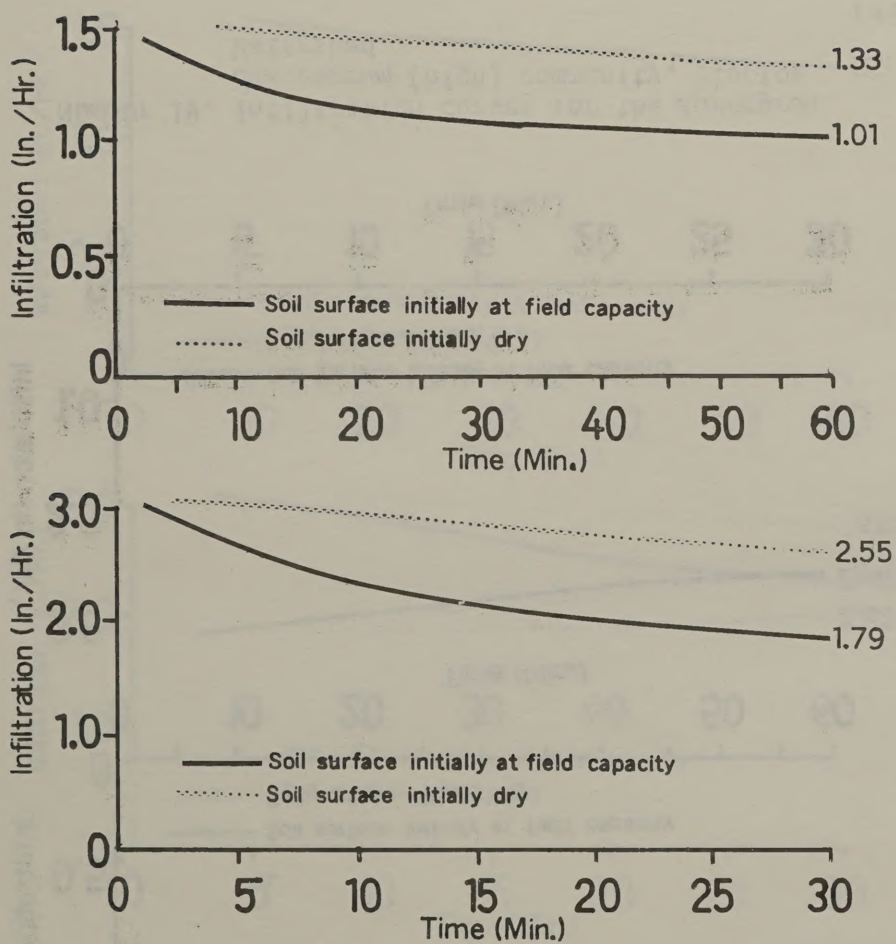
Number 18. Infiltration curves for the *Artemisia tridentata/Agropyron spicatum* community, Steptoe Watershed.



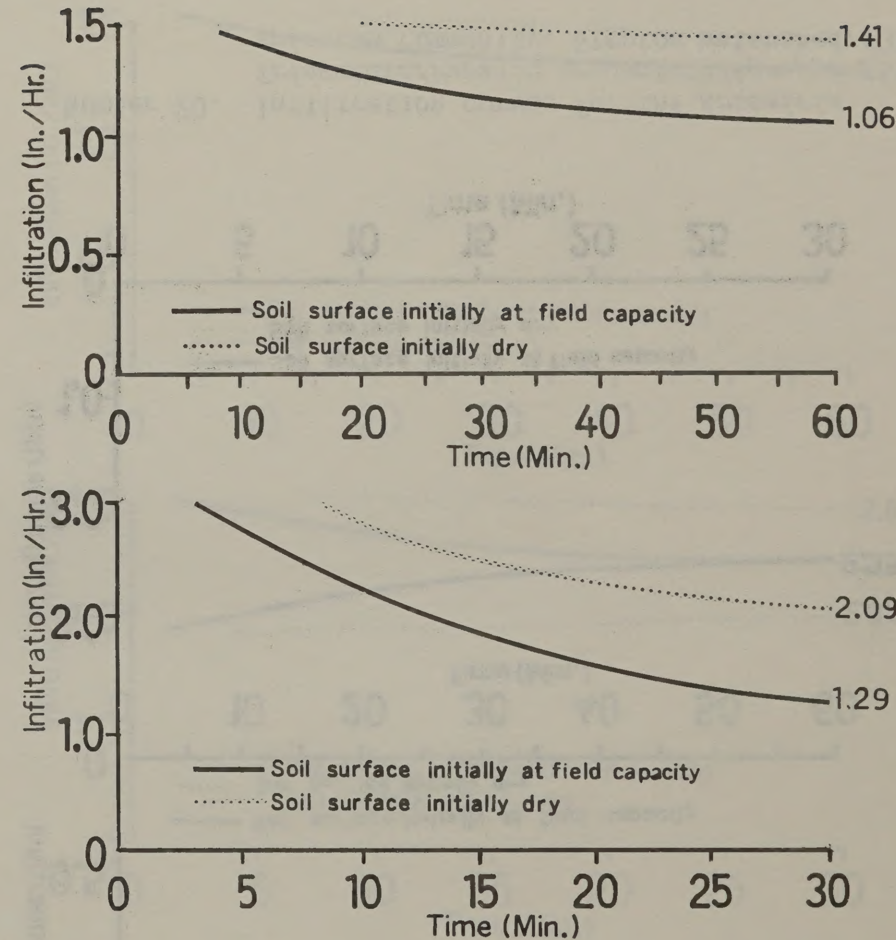
Number 19. Infiltration curves for the *Agropyron desertorum* (high) community, Steptoe Watershed.



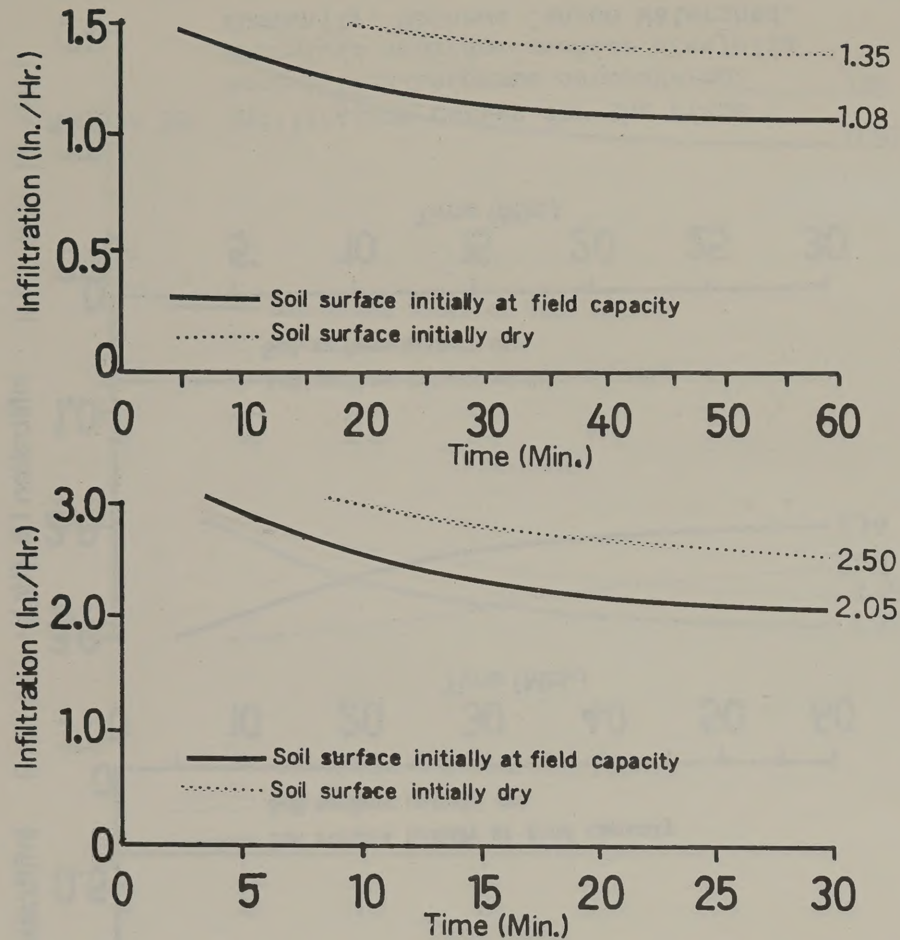
Number 20. Infiltration curves for the *Artemisia Tridentata/Purshia tridentata/Agropyron spicatum* community, Steptoe Watershed.



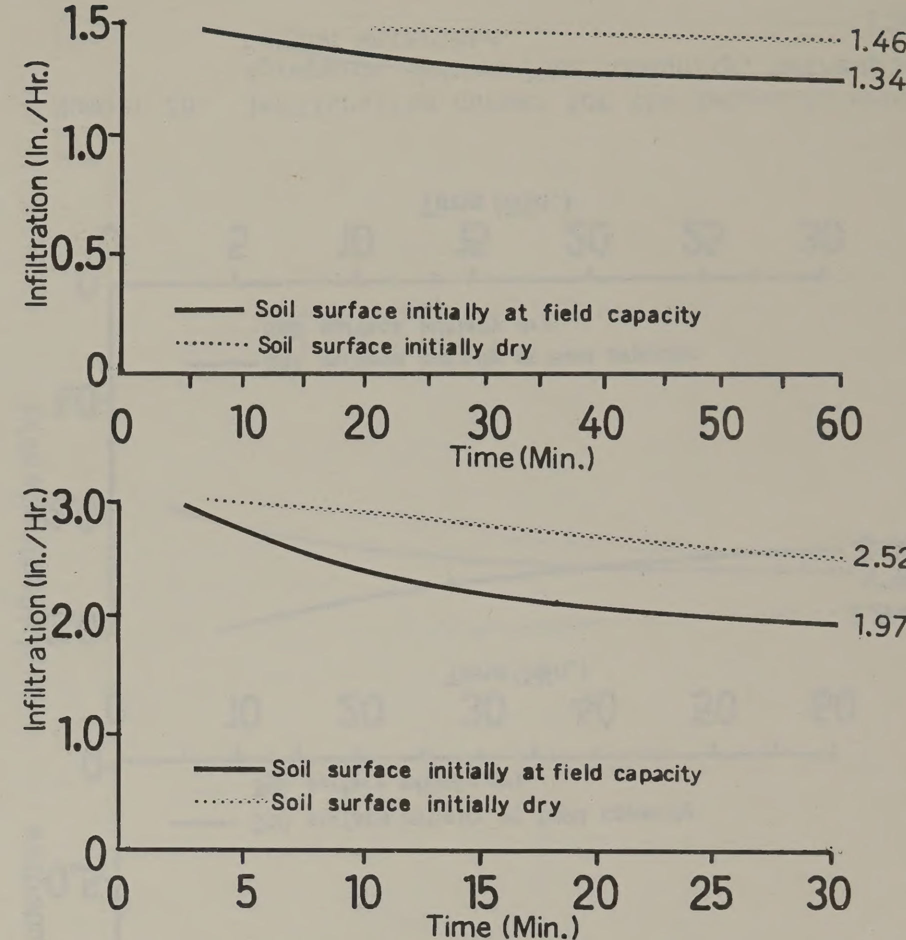
Number 21. Infiltration curves for the *Pinus monophylla/Juniperus osteosperma* community, Steptoe Watershed.



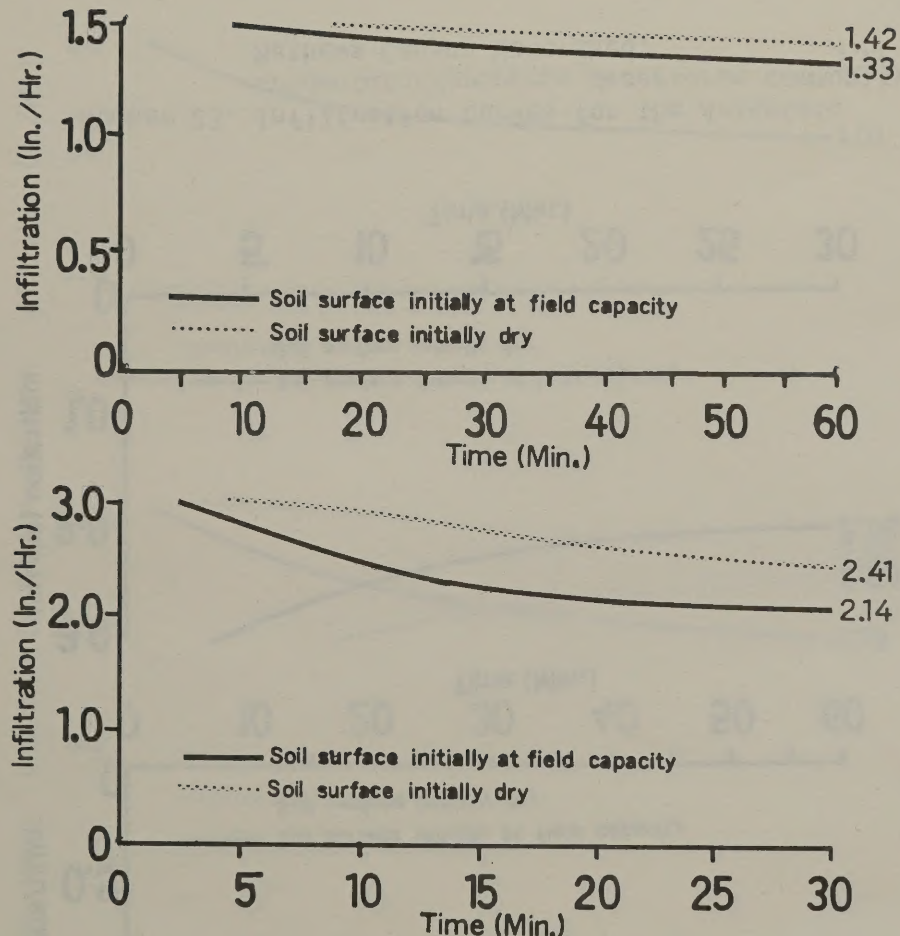
Number 22. Infiltration curves for the *Artemisia tridentata/Chrysothamnus nauseosus* community, Mathews Canyon Watershed.



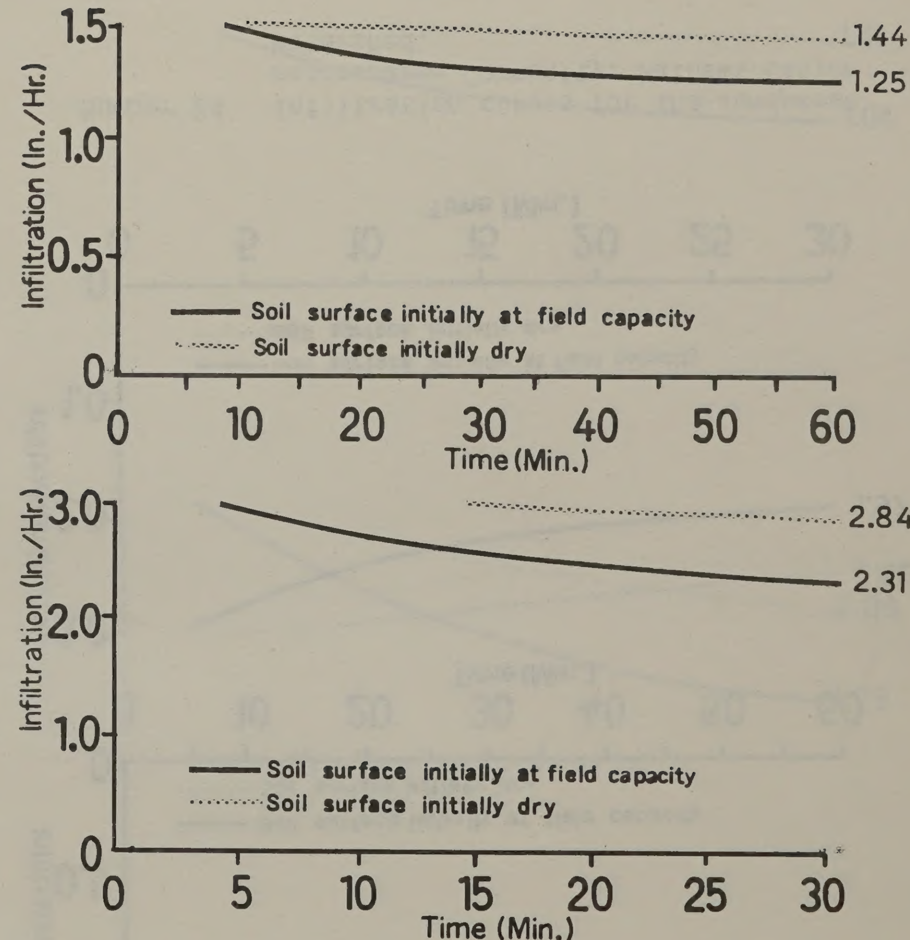
Number 23. Infiltration curves for the *Artemisia tridentata/Agropyron desertorum* community, Mathews Canyon Watershed.



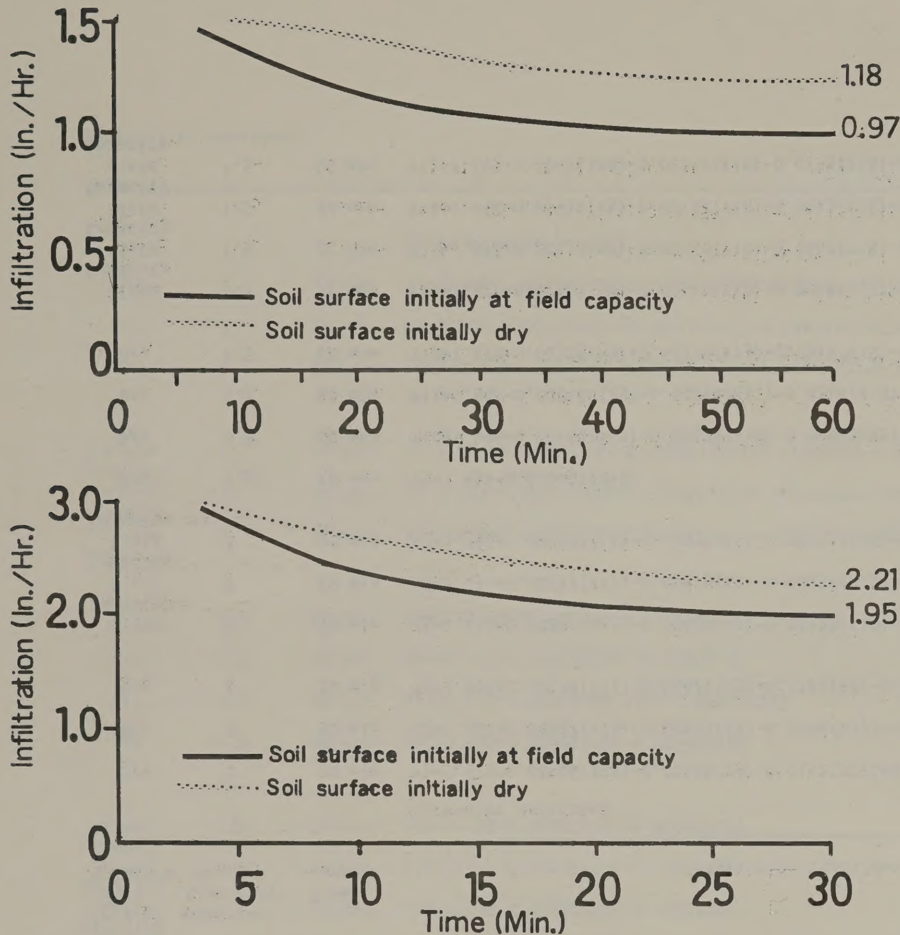
Number 24. Infiltration curves for the *Juniperus osteosperma* Community, Mathews Canyon Watershed.



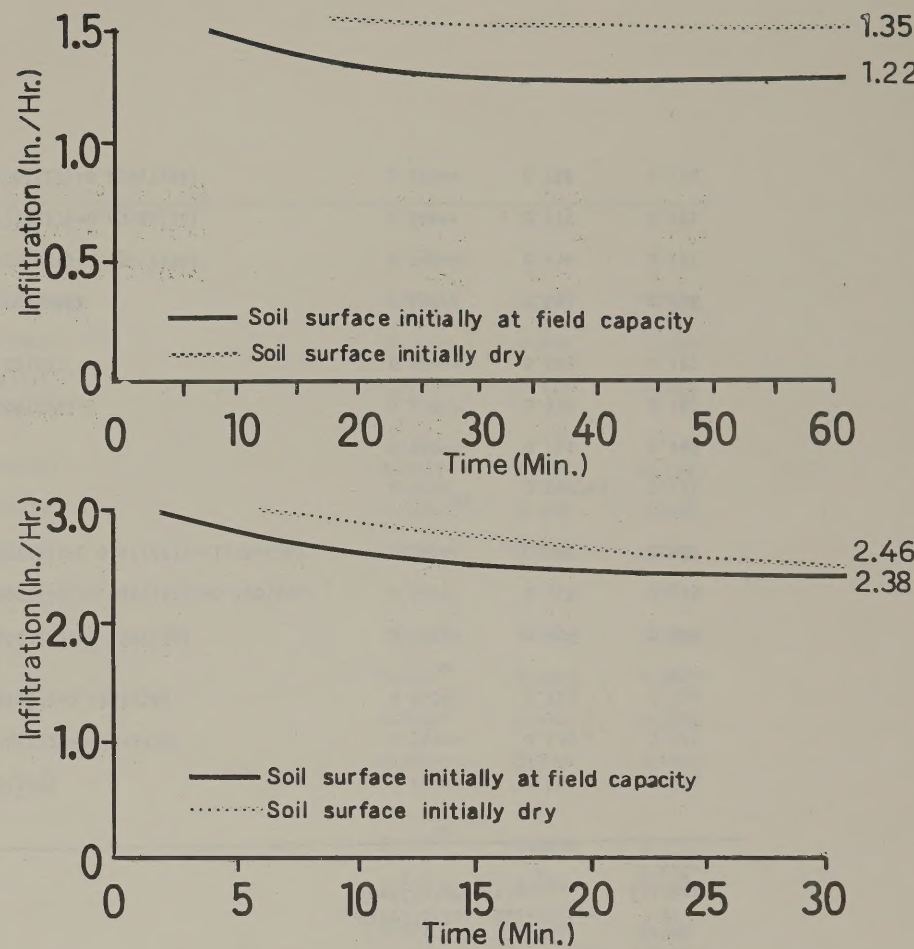
Number 25. Infiltration curves for the *Pinus monophylla/Juniperus osteosperma/Artemisia nova/Amelanchier alnifolia* community, Mathews Canyon Watershed.



Number 26. Infiltration curves for the *Artemisia nova/Agropyron intermedium* community, Mathews Canyon Watershed.



Number 27. Infiltration curves for the *Juniperus osteosperma/Artemisia tridentata/Sitanion hystrix* community, Pine Canyon Watershed.



Number 28. Infiltration curves for the *Juniperus osteosperma/Agropyron desertorum* community, Pine Canyon Watershed.

Appendix B. Regression Equations By Time Interval

Initial Soil Moisture	Application rate (in/hr)	Time Interval	Regression Equations	Correlation Coefficient R	Coefficient of Determination R^2	Standard Error of Estimate S.E.E.
			Duckwater Watershed			
Dry	3	10 min	Y1=2.573+0.00406(X13)-0.00168(X9)-0.0152(X27)+0.102(X36)	0.634**	0.402	0.272
Dry	3	20 min	Y2=2.561+0.00937(X13)-0.00255(X9)-0.0846(X17)-0.0252(X27)+0.124(X36)	0.755**	0.570	0.375
Dry	3	30 min	Y3=2.808+0.00738(X13)-0.00471(X9)-0.128(X18)-0.0337(X27)+0.123(X36)	0.850**	0.723	0.337
Field Capacity	3	10 min	Y5=2.613+0.00291(X13)-0.00670(X9)-0.00120(X10)-0.0364(X27)+0.144(X36)	0.771**	0.594	0.382
Field Capacity	3	20 min	Y6=2.831+0.00267(X13)-0.00815(X9)-0.00235(X10)-0.0965(X18)-0.0364(X27)+0.120(X36)	0.847**	0.718	0.375
Field Capacity	3	30 min	Y7=2.865+0.00258(X13)-0.00994(X9)-0.00213(X10)-0.147(X18)-0.0341(X27)+0.118(X36)	0.865**	0.748	0.380
Dry	1.5	10 min	Y9=1.454-0.000491(X10)	0.0274^{NS}	0.000749	0.171
Dry	1.5	20 min	Y10=1.496+0.00164(X13)-0.00638(X18)-0.00543(X27)	0.388**	0.151	0.148
Dry	1.5	30 min	Y11=1.561-0.000488(X9)+0.00248(X13)-0.0318(X18)-0.00832(X27)	0.578**	0.334	0.167
Dry	1.5	60 min	Y12=1.679-0.00309(X9)+0.00278(X13)-0.0584(X18)-0.0120(X27)	0.750**	0.563	0.182
Field Capacity	1.5	10 min	Y14=1.370-0.00267(X9)-0.00144(X10)-0.00864(X27)+0.0555(X36)	0.658**	0.433	0.176
Field Capacity	1.5	20 min	Y15=1.576-0.00433(X9)-0.00160(X10)-0.0462(X18)-0.0120(X27)+0.0347(X36)	0.796**	0.634	0.185
Field Capacity	1.5	30 min	Y16=1.608-0.00544(X9)-0.00155(X10)-0.0649(X18)-0.0132(X27)+0.0359(X36)	0.846**	0.715	0.182
Field Capacity	1.5	60 min	Y17=1.653-0.00674(X9)-0.00157(X10)-0.0773(X18)-0.0156(X27)+0.0383(X36)	0.888**	0.788	0.176

Appendix B. continued.

			Coils Creek Watershed			
Dry	3	10 min	Y1=3.224-0.000509(X9)-0.00244(X10)-0.0324(X18)-0.00594(X27)	0.560**	0.314	0.199
Dry	3	20 min	Y2=3.238-0.00187(X9)-0.00619(X10)-0.104(X18)-0.00351(X27)	0.805**	0.648	0.255
Dry	3	30 min	Y3=3.243-0.00121(X9)-0.00835(X10)-0.144(X18)-0.00304(X27)	0.848**	0.719	0.283
Field Capacity	3	10 min	Y5=3.275-0.00404(X9)-0.00878(X10)-0.116(X18)-0.00311(X27)	0.815**	0.664	0.338
Field Capacity	3	20 min	Y6=3.268-0.00437(X9)-0.0115(X10)-0.145(X18)-0.00694(X27)	0.805**	0.648	0.448
Field Capacity	3	30 min	Y7=3.386-0.00230(X9)-0.0144(X10)-0.170(X18)-0.00913(X27)	0.901**	0.812	0.345
Dry	1.5	10 min	Y9=1.479-0.06353(X9)^2+0.0176(X16)	0.249^{NS}	0.0623	0.0143
Dry	1.5	20 min	Y10=1.503+0.00529(X9)^2-0.038(X16)	0.228^{NS}	0.0519	0.0610
Dry	1.5	30 min	Y11=1.512-0.00000404(X9)^2-0.0565(X16)	0.492**	0.242	0.0794
Dry	1.5	60 min	Y12=1.538-0.00348(X9)-0.0886(X16)	0.000**	0.479	0.0997
Field Capacity	1.5	10 min	Y14=1.478-0.00220(X9)-0.0304(X16)	0.284^{NS}	0.0805	0.145
Field Capacity	1.5	20 min	Y15=1.524-0.00472(X9)-0.107(X16)	0.636**	0.404	0.147
Field Capacity	1.5	30 min	Y16=1.498-0.00663(X9)-0.112(X16)	0.677**	0.459	0.155
Field Capacity	1.5	60 min	Y17=1.460-0.00943(X9)-0.114(X16)	0.748**	0.559	0.155

Appendix B. continued.

			Steptoe Watershed			
Dry	3	10 min	Y1=5.946-0.000376(X10)-2.874(X16)-0.0564(X18)	0.804**	0.646	0.045
Dry	3	20 min	Y2=10.159-0.00176(X10)-7.045(X16)-0.0898(X18)	0.742**	0.550	0.119
Dry	3	30 min	Y3=10.119-0.00286(X10)-7.006(X16)-0.106(X18)	0.660**	0.436	0.166
Field Capacity	3	10 min	Y5=2.40+0.00274(X11)-0.182(X18)+0.0972(X35)	0.706**	0.498	0.205
Field Capacity	3	20 min	Y6=1.466+0.0247(X11)-0.000188(X11)^2-0.00309(X9)-0.149(X18)+0.162(X35)	0.792**	0.628	0.245
Field Capacity	3	30 min	Y7=1.405+0.0263(X11)-0.000196(X11)^2-0.00458(X9)-0.163(X18)+0.155(X35)	0.782**	0.612	0.279
Dry	1.5	10 min	Y9=1.50-0.000423(X7)	0.618**	0.382	0.00805
Dry	1.5	20 min	Y10=1.497-0.00182(X7)	0.506**	0.256	0.0465
Dry	1.5	30 min	Y11=1.492-0.00218(X7)-0.00665(X17)	0.540**	0.292	0.0578
Dry	1.5	60 min	Y12=1.494-0.00226(X7)-0.000279(X9)-0.0290(X17)	0.568**	0.323	0.0790
Field Capacity	1.5	10 min	Y14=1.475-0.00404(X7)-0.00228(X9)+0.0388(X15)	0.666**	0.443	0.0807
Field Capacity	1.5	20 min	Y15=1.449-0.00505(X7)-0.00447(X9)+0.0697(X15)	0.662**	0.439	0.117
Field Capacity	1.5	30 min	Y16=1.390-0.00521(X7)-0.00466(X9)+0.000474(X13)+0.0649(X15)	0.637**	0.406	0.139
Field Capacity	1.5	60 min	Y17=1.297-0.00541(X7)-0.00492(X9)+0.00104(X13)+0.0684(X15)	0.636**	0.405	0.158

Appendix B. continued.

			Pine and Mathews Canyon Watersheds			
Field Capacity	3	10 min	$Y1=2.862+0.00981(X12)+0.391(X15)-0.0289(X25)$	0.794**	0.631	0.301
Field Capacity	3	20 min	$Y2=4.006-0.00446(X9)+0.00170(X12)+0.139(X15)-0.00109(X10)-0.0384(X25)$	0.736**	0.541	0.265
Field Capacity	3	30 min	$Y3=3.987-0.00404(X9)+0.00392(X12)+0.219(X15)-0.00169(X10)-0.0457(X25)$	0.813**	0.661	0.281
Dry	3	10 min	$Y5=2.904-0.0162(X7)+0.00473(X13)-0.00568(X9)-0.00332(X10)$	0.820**	0.673	0.287
Dry	3	20 min	$Y6=2.859-0.0228(X7)+0.00421(X13)-0.00616(X9)-0.00643(X10)$	0.884**	0.781	0.309
Dry	3	30 min	$Y7=2.863-0.0255(X7)+0.00390(X13)-0.00582(X9)-0.00822(X10)$	0.894**	0.799	0.332
Field Capacity	1.5	10 min	Y9=No Equation			
Field Capacity	1.5	20 min	$Y10=1.501-0.0000161(X9)^2-0.0000592(X10)+0.0003154(X13)$	0.662**	0.439	0.0440
Field Capacity	1.5	30 min	$Y11=1.491-0.0000352(X9)^2-0.000205(X10)+0.000800(X13)$	0.759**	0.576	0.0753
Field Capacity	1.5	60 min	$Y12=1.468-0.0000562(X9)^2-0.000435(X10)+0.00133(X13)$	0.776**	0.603	0.116
Dry	1.5	10 min	$Y14=1.471-0.00167(X9)+0.000689(X13)$	0.465**	0.216	0.0927
Dry	1.5	20 min	$Y15=1.594-0.00308(X9)-0.0000288(X9)^2+0.00115(X13)-0.00499(X25)$	0.708**	0.501	0.152
Dry	1.5	30 min	$Y16=1.658-0.00375(X9)-0.0000381(X9)^2+0.00109(X13)-0.00727(X25)$	0.741**	0.549	0.172
Dry	1.5	60 min	$Y17=1.723-0.00535(X9)-0.0000404(X9)^2+0.00102(X13)-0.00942(X25)$	0.778**	0.606	0.190

Appendix B. continued.

Combined Analysis						
			Duckwater and Coils Creek Watersheds			
Dry	3	30 min	Y3=3.186-0.00358(X10)+0.00314(X13)-0.188(X18)-0.0185(X27)+0.0233(X36)	0.809**	0.654	0.350
Field Capacity	3	30 min	Y7=3.169-0.00987(X10)+0.00282(X13)-0.193(X18)-0.0120(X26)+0.0302(X36)	0.801**	0.741	0.391
Dry	1.5	60 min	Y12=1.661-0.00325(X9)+0.00169(X13)-0.0645(X18)-0.00944(X27)	0.744**	0.554	0.166
Field Capacity	1.5	60 min	Y17=1.803-0.00693(X9)-0.00183(X10)-0.124(X18)-0.00813(X27)	0.867**	0.75	0.175
			Duckwater, Coils Creek and Steptoe Watershed			
Dry	3	30 min	Y3=3.329-0.00263(X10)+0.00419(X13)-0.222(X18)-0.00749(X27)-0.0136(X30)	0.810**	0.657	0.340
Field Capacity	3	30 min	Y7=3.093-0.00338(X9)-0.00790(X10)+0.00213(X13)-0.238(X18)-0.0109(X26)+0.0326(X36)	0.839**	0.704	0.407
Dry	1.5	60 min	Y12=1.632-0.00296(X9)-0.0832(X18)+0.106(X20)-0.00747(X27)	0.739**	0.546	0.160
Field Capacity	1.5	60 min	Y17=1.647-0.00672(X9)-0.00112(X10)-0.158(X18)	0.838**	0.702	0.185
			Duckwater, Coils Creek, Steptoe, Pine and Mathews Canyon Watersheds			
Dry	3	30 min	Y3=3.121-0.00593(X10)-0.163(X18)+0.175(X20)-0.00931(X30)	0.711**	0.505	0.393
Field Capacity	3	30 min	Y7=3.074-0.0119(X10)-0.176(X18)+0.184(X20)-0.00958(X30)	0.794**	0.630	0.447
Dry	1.5	60 min	Y12=1.528-0.00332(X9)+0.0009(X13)-0.0759(X18)	0.631**	0.399	0.178
Field Capacity	1.5	60 min	Y17=1.598-0.00761(X9)-0.000998(X10)-0.0934(X17)	0.724**	0.524	0.230

NS = Non Significant at .05 Level

** = Significant at .01 Level

APPENDIX C.
Glossary

Coppice dune - the area of accumulation of litter and soil under shrubs and bunch grasses.

Dune interspace - the area between coppice dunes.

Field capacity - the water that a soil **in situ** retains after drainage for 24 hours.

Infiltration rate = infiltration capacity - the rate o of penetration of still, clear water downwards into a soil.

Infiltrometer = rain simulator - a device for measuring the infiltration rate of a soil, the water being delivered uniformly over an area at a given rate or in a given volume.

Plant cover - takes into account both overstory and understory cover - thus it is possible to have more than 100 percent total cover.

Sediment production - the material product of erosion (soil, sand, clay, silt, gravel) by simulated rainfall on runoff plots.

Soil hydrologic groups - soils grouped according to their in-place infiltration rate, after prolonged wetting. Soils are classified in four hydrological soil groups, A, B, C, and D with A having the highest and D the lowest intake rates.

Vesicular horizon - a surface horizon that has vesicular pores and either massive or platy structure. It is an indication of unstable soil when nearly saturated.

Watershed - the total land area, regardless of size, above a given point on a waterway that contributes runoff water to the flow at that point.